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BACKGROUND PAPER OUTLINING THE RATIONALE AND STATEGIC NEEDS FOR RAIL FREIGHT DEVELOPMENT IN CANADA

prepared for the

Transportation Development Centre

by

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17. Abstract

This study recommends a set of research and development priorities for rail freight technology in Canada. These recommendations derive from consultation with the railways, the railway supply industry and government. Forecasts of railway activity as influenced by markets and the economy were used to identify which R&D priorities were strategic for Canada.

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17. Resume

Rapport concernant les travaux de R&D à exécuter prioritairement en matière de transport ferroviaire de marchandises au Canada, et qui ont été cernés à partir des besoins exprimés par les milieux intéressés: sociétés de chemins de fer, constructeurs de matériel roulant et pouvoirs publics. Les prévisions du trafic ferroviaire établies en fonction de la conjoncture économique et commerciale ont servi à identifier les secteurs d'activité au Canada où la R&D devrait recevoir la plus haute priorité.

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SUMMARY

In anticipation of a submission to Treasury Board for an extension of the Augmented Rail Freight Program (ARFP), the Canadian Institute of Guided Ground Transport was contracted to prepare a background paper on rail freight R&D.

Consultation with railways, suppliers and government supplemented market analysis in the formulation of the following strategic research and development priorities:

- Advanced train control sub-systems:
  - coordination and support of Canadian suppliers
- Innovative rolling stock design:
  - development of expertise to generate Canadian designs for emerging specialty equipment markets
- Track system construction/maintenance:
  - optimization of track systems to improve the utilization of fixed plant and minimize additional capital investment
- Infrastructure configuration:
  - examination of alternatives for matching capacity to demand (high and low)
- Electrification:
  - continued improvement of data base to identify optimal implementation scenario
- Rail freight data base:
  - as part of a larger transportation data base, develop reference data to aid in determining and assessing potential developments
- Materials analysis/development:
  - development of expertise to test/demonstrate novel materials applications to equipment and track design
- Development facilities:
  - provision of focal facility and group to aid firms in the earlier, riskier aspects of technology development.

SOMMAIRE

Devant soumettre au Conseil du Trésor un document justifiant la prolongation du programme élargi sur le transport ferroviaire de marchandises, le CDT a confié au Canadien Institute of Guided Ground Transport le mandat d'établir un mémoire concernant la recherche à faire dans ce domaine.

Après consultation avec les divers milieux intéressés: sociétés de chemins de fer, constructeurs de matériel roulant et pouvoirs publics, et examen des études de marché publiées, le contractant a mis en lumière les travaux prioritaires de R&D dans le domaine visé:

- Sous-systèmes avancés pour le contrôle automatique des trains: coordonner et soutenir les constructeurs canadiens.

- Matériel roulant de conception innovante: rassembler les compétences capables de concevoir au Canada des matériels destinés à alimenter le marché naissant des équipements spécialisés.

- Construction et entretien des voies: optimiser les voies ferrées de manière à tirer le plus grand parti possible des énormes immobilisations qu'elles représentent.

- Infrastructure ferroviaire: envisager les moyens d'ajuster la capacité du réseau ferroviaire à la demande (forte ou faible).

- Électrification: enrichir toujours plus la base de données nécessaires pour mettre au point des scénarios d'implantation optimale.

- Base de données sur le transport ferroviaire de marchandises: à intégrer à la base de données plus large des transports en général et à utiliser pour jauger le potentiel de développement et évaluer les possibilités qui s'offrent.

- Etude et mise au point de matériaux: étudier des méthodes d'essai nouvelles relativement à certains matériaux innovants introduits dans le domaine ferroviaire (matériel et voie).

- Centre de recherche ferroviaire: créer un centre de recherche ferroviaire dont le mandat serait d'aider l'entreprise privée dans les premières phases toujours plus risquées, du développement de technologies nouvelles.

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1. THE GROUND TRANSPORTATION SYSTEM IN NORTH AMERICA

The Canadian railway system is the product of historical and continental influences. Railways have always been crucial to the resource-based economies of the U.S. and Canada, and the development of competitive freight and passenger modes has affected both transportation networks to a remarkably similar degree.

Railways in North America are virtually all private sector. (CN Rail and Conrail are theoretically public corporations but operate as private sector for purposes of pricing and financial results.) They have traditionally carried a heavy burden of operating rules and practices which have been a disincentive to technological innovation. The innovation process in the rail sector involves delays and costs which decrease the likelihood of financial reward to railways and industrial developers.

Railway costs are characterized by a high capital investment in track due to geography; a fairly high sensitivity to energy costs; and a strong sensitivity to operating productivity because of the long distances and elapsed time for any given train operation. These factors have favoured the trucking industry in the post-war period. Trucking has few labour restrictions, is intensely competitive, has low capital requirements (indeed any individual can buy a truck and enter the business), and very little regulatory restraint on productivity gains. The unanimity and strength of the trucking lobby is in strong contrast to that of the rail sector.

U.S. railroads have gone through a major shakeout and consolidation in the post-Staggers period (1980). There are now a few mega-railroads. They have reduced track mileage, eliminated surplus employment, concentrated their intermodal operations, and invested heavily in facilities and operating efficiency. The rolling stock utilization of the U.S. roads has risen sharply, leading to a slump in new car procurement. The freight car industry has experienced a drastic contraction as a result.

The railway supply industry has reacted to the constraints on innovation implementation by offering incremental technological improvements only. In addition, the existence of AAR standards, which closely

specify design (rather than performance), has been a levelling factor which minimized technological advantage.

The rationalization of the U.S. railroads into five major systems, and a number of significant secondary roads, has had a radical effect on the industry. Decisions regarding standards are reached much more rapidly by the senior participants, and the receptivity to change is so much higher that attention is now focussed on performance requirements rather than design specifications. The marketing of new products to the mega-roads will be substantially more efficient, but the stakes will be higher on an individual product basis. The development cost risk will be higher due to the greater degree of innovation and the technological factors implicit in a performance competition.

1.1 The OECD Railway Industry

Two factors lead to significant differentiation of the technology of railways outside North America:

- state ownership
- predominant emphasis on passenger traffic.

State ownership leads to a number of organizational characteristics which influence technology development:

(1) The railway has a strategic importance related to transportation system efficiency in serving national objectives.

(2) New investment is determined by a single planning authority which usually includes substantial systems analysis capability.

(3) There is a single-point responsibility for technology innovation and specification.

(4) Funding of new investment is almost never solely related to commercial criteria. Funding cycles are longer and seldom subject to short-term disruption.

The emphasis on passenger traffic leads to a technological focus on speed and reliability. As a consequence, the high-technology subsystems (trucks, brakes, signalling, propulsion) have been intensively

developed for safe and reliable high-speed operation. The transfer of this technology to North America is indirect in the case of freight, due to the emphasis on high axle loads and low speeds. However, as speeds are gradually raised to compete with highway vehicles, off-shore technology has begun to appear in North American vehicles.

Speed has tended to bring off-shore technology to the North American market-place in a shorter cycle time because it accelerates the development process.

Many of the control technologies required for reliable high-speed operation are now being offered in North America for lower-speed freight applications. Propulsion and signalling are obvious examples.

In passenger equipment the surviving North American manufacturers have almost abandoned product development and are licensing off-shore technology at an increasing rate. In view of the technological depth of the off-shore suppliers, it is likely that any major new inter-city passenger program in the U.S. will spark the emergence of foreign-owned U.S. operations to supply this market.

1.2 The Canadian Railway Sector

The significance of railways to Canada cannot be overstated. The total domestic exports of Canada in 1984 were Cdn$109.544 billion. Of this total, Cdn$103.66 billion were heavily, or totally, dependent on rail transportation. Some examples are:

crude ores, metals	Cdn$ 17.351 billion
agricultural products	Cdn$ 10.298 billion
fabricated materials	Cdn$ 35.990 billion
forest products	Cdn$ 10.619 billion
motor vehicles	Cdn$ 29.404 billion

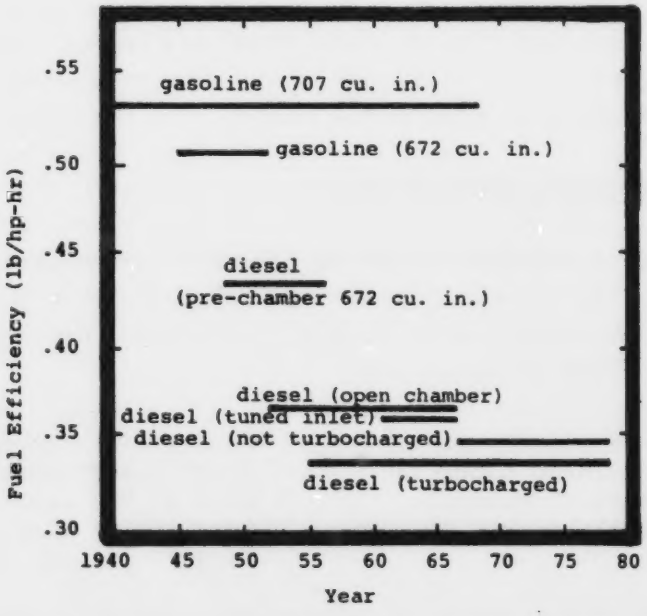
The price of many commodities, FAS our western ports,[1] is highly sensitive to rail costs. For example:

1 1983 average values. Recent negotiations have reduced the price of coal.

	Commodity Price/Ton	Transportation Cost/Ton
coal	73	$15
sulphur	101	$25
potash	94	$25

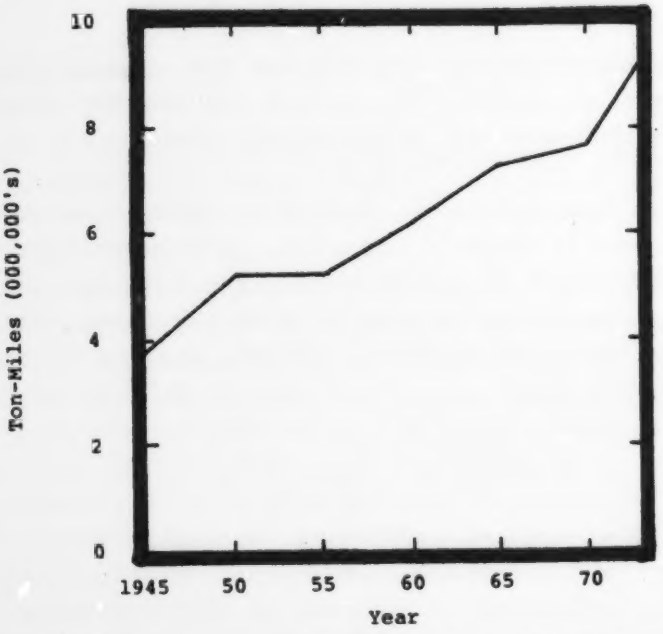
Productivity improvements in the extraction industries are possible, but they will be financed only if a stable market situation is foreseen. New off-shore suppliers will exert price pressure on many of our commodity exports. In this situation the railways will be under intense pressure to be more competitive than at present.

The Canadian rail system has achieved significant productivity improvements through equipment technology in the past twenty-five years. The efficiency and scale of the diesel engine (Figures 1 and 2) and the carload capacity (Figure 3) have been two of the major contributors.



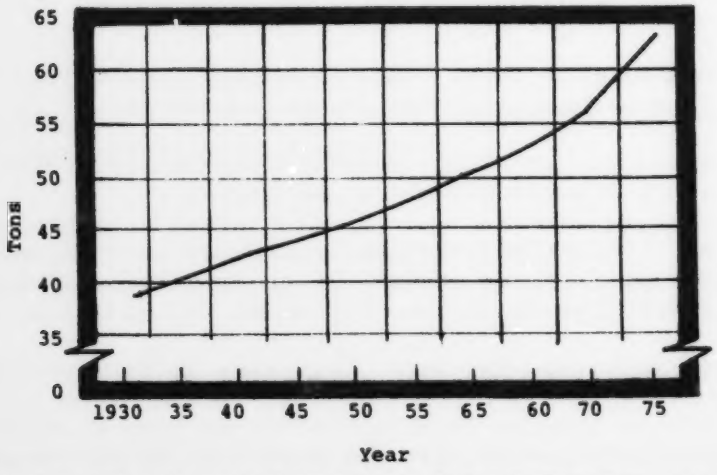
Source: Truck and Rail Technological Developments to 1990, prepared by R.S. Wallace & Associates Limited for the Research Branch, Canadian Transport Commission, 1978.

Figure 1 Evolution of heavy-duty truck engine fuel efficiency



Source: Truck and Rail Technological Developments to 1990, prepared by R.S. Wallace & Associates Limited for the Research Branch, Canadian Transport Commission, 1978.

Figure 2 Average ton-miles per power unit -- intercity service, United States, 1945-1973



Source: Truck and Rail Technological Developments to 1990, prepared by R.S. Wallace & Associates Limited for the Research Branch, Canadian Transport Commission, 1978.

Figure 3 Average freight car capacity, 1926-1975

The historical sources of improvement are now approaching limits and the future areas of productivity growth will be in control systems, reduced track maintenance and operating rule changes.

A major problem experienced by U.S. and Canadian railways has been the erosion of market share. Ton-miles, as a percentage of the total market, have decreased in North America from the immediate post-war high of 60 per cent to a recent level of 40 per cent. The erosion of absolute tonnage has been even more severe, and the total rail tonnage has been relatively static for five years, if the 1981-83 recession is factored out.

At this time the railways are concerned that the highway trucking industry is on the verge of penetrating the bulk commodity traffic due to the imminence of truck-trains. Ontario has already doubled allowable truck tonnages (compared to the rest of North America) and other jurisdictions are likely to follow eventually.

The sensitivity of rail operations to productivity improvement shows that significant leverage exists. Some examples are:

- elimination of one brakeman would increase train crew productivity by 20 per cent, amounting to an estimated saving of $60 million per annum for the Canadian system
- automated trains and terminals could reduce Canadian costs by $300 million per annum
- a one per cent improvement in maintenance productivity is worth $10 million per year
- an increase in locomotive availability from 85 to 90 per cent would result in an avoidance of $250 million investment over ten years.

1.3 Strategic Objectives of Rail Freight R&D

It is virtually unarguable that the Canadian rail system must demonstrate progress in three areas:

(1) Penetration of higher value-added and profit markets (primarily intermodal)

(2) Rationalization of regulatory restrictions which inhibit innovation.

(3) New technology which reduces maintenance costs and substantially increases operating efficiency, as the basis of a revitalized railway supply industry.

All three are related and highlight the need for a coordinated effort between Transport Canada, the Canadian Transport Commission, and the railways. The current fiasco involving the introduction of End-of-Train Units is only the first act in the accelerating rate of new technology introduction. The Advanced Train Control System could be disastrously delayed if the ETU process is repeated.

If real fuel prices increase after 1990 (leading to higher operating costs and prices, and loss of market share), and if pressure on commodity prices in the world market develops as expected, the railways will be faced with declining tonnage just as the capacity expansion of the 80s is completed. The dependence on rail system efficiency will be heightened in this scenario, since truckers have shown a more rapid adaptation to operating improvements and experience less impediments from the regulatory authorities.

This trivial risk analysis does not begin to accommodate general inflation and labour rate increases which are inevitable.

The ARFP must, therefore, be oriented toward achievement of the objectives stated above. This implicitly defines the role and responsibility of Transport Canada in managing the ARFP.

(1) **Definition of needs.** The supply industry requires specified product development objectives. For competitive reasons the railways have been reluctant to do this in the past.

(2) **Development of resources.** Rail industry development in Canada is fragmented and short term. Key programs such as ATCS and HPIT require concentrated resources, depth of expertise and staying power. Few individual companies have this in Canada.

(3) **Focus on strategic priorities.** Past experience of both government and industry shows that scarce

resources are too thinly spread. The key developments must receive the lion's share of the available funds. This implies an effective working relationship between government, industry and the railways.

The well-intended policy of shared development costs has favoured the small, lower-risk projects at the cost of sustained higher-risk R&D which is more difficult to predict accurately.

The railways have, in the ATCS and HPIT programs, begun to produce performance requirements rather than design specifications. This process must be continued as an important input to strategic priority analysis.

(4) **Capability to implement marketing and production.** The industry must adapt to a larger scale of development by appropriate business linkages and the creation of Canadian expertise. Production follows product development -- not vice versa -- and in a competitive international industry, spreading the manufacturing overhead is an inadequate strategy.

Transport Canada must ensure that railway requirements definition is utilized by the development teams and is maintained as the definitive requirement by a close and effective advisory relationship. Marketing after-the-fact in a capital goods market dominated by few customers is a fast route to business failure.

It must also ensure that Canadian expertise is developed so that a true capability to deliver and support the resultant products is achieved.

Since R&D must logically culminate in demonstration and deployment, there is a critical need for the various involved ministries to cooperate effectively. Transport Canada, as the initiator of the R&D, must take the lead in developing cooperation.

(5) **Development of regulatory support.** This is an area in which the other advanced railway technology countries of the OECD make Canada look distinctly amateurish. No major railway system technology in Europe or Japan has been implemented without preparatory approval and acceptance by safety and public interest bodies. The existing reactive

system in Canada is a serious disincentive to any industrial developer. It stretches out the development and demonstration cycle to an uneconomic degree, and usually impedes the objective review and acceptance of performance criteria. The latter must become part of the front-end requirement rather than the debate-after-the-fact. It would be logical for Transport Canada to take the lead in initiating a rational approval process.

2. TASK DISCUSSIONS

The following text summarizes data gathered to fulfill the work statement tasks. The interviews, forecasts and analyses are based on the material referenced, supplemented by the experience of CIGGT staff.

2.1 Stakeholders' Input (Task 5.3)

Within the time frame allotted, contacts were arranged with the individuals and organizations listed in Table 1. Comments received were retrospective, introspective and prospective on the topic of rail freight R&D within the mandate of the ARFP. Specific comments will be referenced in Section 3 where the prioritization process and recommendations are described.

2.2 Current Market Environment (Task 5.4)

A review of the current railway and supply industry environment, in terms of technological and financial status, was requested. Technological status is discussed on an industry-wide basis, with reference to specific Canadian capabilities where applicable. The financial status of the railways is presented, with accompanying aggregate figures for U.S. Class I railways.

The changing environment for the railway industry in Canada will affect railway suppliers, old and new, and will result in altered transportation networks to service business and passenger needs. An examination of the relative capabilities of the supply industry in light of the opportunities available was performed to aid in identifying where R&D funding could be applied. The Canadian Institute of Guided Ground Transport (CIGGT), as part of its continuing activities, has been analyzing the emerging product opportunities. Over the past year, these opportunities have been assessed against capabilities existing in Canada and the potential impact of industry trends. Major manufacturers were contacted to determine their planned response to market changes, considering current conditions and resources available. Some smaller manufacturers who were addressing the market with new technologies or products were contacted. Discussion of the industry's abilities to meet current and future market demands will follow a description of market trends and specific projects.

TABLE 1

DISCUSSIONS WITH INTERESTED PARTIES

Organization	Personnel	Responsibility
DRIE	J. Kritsch	Urban and Railway Systems Division
	E. Cuylits	Manager, Urban and Railway Systems Division
TC-Surface	A.E. Pokotylo	Railway Freight Director
	P. Hoisak	Chief, Capacity and Economics
	T. Ganton	Rail Systems Analyst
CP Rail	R. Klein	Assistant Vice-President, Research
	A. Bethune	Director, Technical and Operations Research
CNR	H. Girard	Research Engineer
RAC/RAB	P. Detmold	Chairman
	CIGGT staff	Committee members
CTC	J. Chisholm	Director, Maintenance Division, Engineering Branch
CRTMA	R. Winsor	President
Bombardier	R. Bergner	Director, Engineering Programs
Hawker Siddeley	R. Quan	Director of R&D
CITL	J.D. Long	President
	J. Dion	Policy Analyst
NRC	C.A.M. Smith	Railway Lab
Glenayre/DSL	G. Millet	Special Projects

2.2.1 Product Opportunities

Market opportunities arise through growth in existing product groups or by the new application of technologies. Industry purchasing of various conventional railway products reflect the past recession(s) and concurrent low levels of investment in equipment.

This analysis breaks the rail system into its major subsystems (Figure 4); subsystem market opportunities are discussed with respect to major components or principal characteristics.

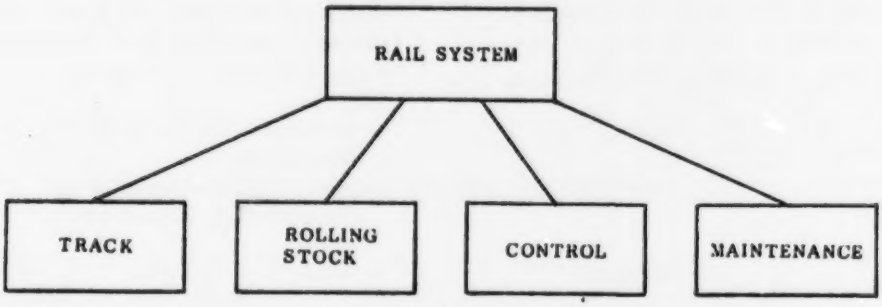


Figure 4 Strategic product groups

Track

Rail. The rail market is becoming increasingly segmented as new rail sections and metallurgy are developed to cope with the severe demands of modern traffic. While standard carbon rail is still the economic choice in most cases, alloyed or heat-treated premium rails offer benefits where extreme wear is encountered, as in curves or heavy-haul service, and rail replacement is expensive or disruptive.

Current research into alternate track structures, led by applications in rail transit, include redesign of the conventional I-beam rail section. Continuous track foundations and other track modifications could lead to other rail sections more suited to the desired track moduli.

Fasteners. As part of the overall track system, fasteners constrain the rail within the desired geometry, and are a factor in track response due to their relative restraint characteristics. A plethora of fastening systems has been marketed in response to the growing variety of track systems. Combinations of clips, bolts, pads and other fixation devices

provide the track designer with wide-ranging choices for specific applications. The market is not saturated, however, and research into more optimally matched track system response is continuing.

New fasteners fall into two general groupings: those that improve the performance and long-term cost of conventional track; and those that are developed as part of novel track concepts.

Ties. Alternatives to wood ties have been sought and developed in many instances in the past. In general, few alternatives have offered superior performance for lower cost. Heavy-haul situations, requirements for higher ride quality for passenger systems, and other special situations have justified the use of concrete ties, steel ties or concrete slab track. Ties made from plastic, chipped wood composite and other synthetic materials are also under development.

The key characteristics of wood tie substitutes are better durability for given traffic, consistency of material response, and more precise location of track. These characteristics address the need for improved maintenance of tolerances. Closer, more consistent tolerances reduce maintenance costs and permit higher-speed operations with less disruption for maintenance.

As with fasteners, research into wood tie substitutes either attempts to mimic wood tie performance at lower cost or strives to provide superior track performance through innovative design and use of materials at a premium price.

Miscellaneous Track Components. Discontinuities in track occur at switch points, crossovers and in bolted track. The impact loadings and wear that occur at these locations require additional maintenance expenditures to maintain track integrity. Materials research and designs intended to reduce maintenance costs have been pursued, but are limited in use to where the benefits accrued offset the premiums paid for the special equipment. Ever-increasing vehicle loads and/or higher operating speeds will increase such usage.

A number of other means of improving track performance have been developed. Geotextiles and geogrids can stabilize ballast and improve drainage. Lime injection has been used to "cement" ballast for a more

solid support. Asphalt has been used in single layers or to sandwich ballast. The message conveyed by these developments is simple. Railways are considering innovative means of dealing with both general and specific track problems. For some components, the potential payoffs are very large, considering the volume of materials applied to new construction or replaced on a continuing basis.

Rolling Stock

Motive Power. Canada's two major railways face major motive power renewal requirements over the 1986-to-2000 time period. It is estimated that replacements or major rebuilds of existing twenty to twenty-five year old mainline 3,000 hp equipment will average 85 units per year. With the effects of traffic growth considered, the total requirement will be in the order of 100 units annually. These equipment acquisition/renewal decisions have significant cost implications, not only in terms of purchase price but also for life-cycle operating costs. By discounting the expected operating costs for an existing diesel-electric locomotive to an equivalent present value, the life-cycle value of each locomotive purchase can be assessed:

first cost:	$ 1.5 million
present value of maintenance:	2.1 million
present value of fuel:	7.3 million
	$10.9 million

Thus, the decisions made regarding motive power to the end of this century will involve a life-cycle value commitment on the order of $1 billion annually. The importance of maintenance and fuel requirements relative to first cost is evident, and explains current interest in three-phase traction motors, alternative fuels and electrification.

The first cost in itself is also significant and has created initiatives towards increasing adhesion utilization and power/weight ratios. The AAR concept of the "integral train" is also examining peak/average power demands with a view to identifying economical short-term capacity options.

While the Canadian railways will face major decisions over the next few years concerning motive power on their main lines, Canadian manufacturers must also decide what research and development projects for freight locomotives, transmission systems and other locomotive components are likely to be commercially successful (see Figure 5). For these decisions to be soundly based, it is essential that the cost-effectiveness of alternative locomotives and sub-systems be established as accurately as possible. As the payback period for major electrification is unlikely to be less than fifteen years, and could well be more than twenty years, it is also important that the probability of long-term cost breakthroughs for alternative systems such as coal and natural gas be known.

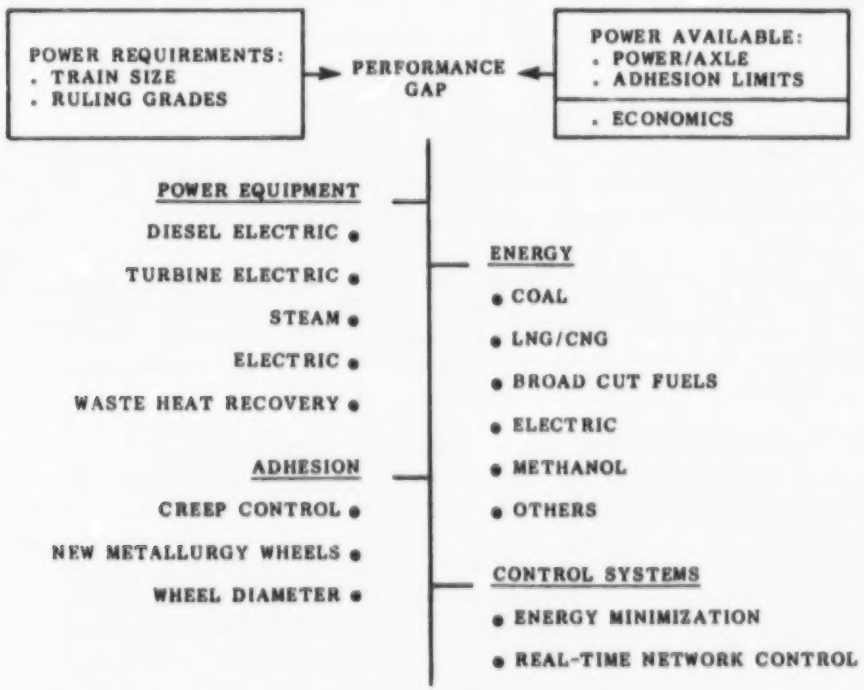


Figure 5 Motive power

The CN and CP systems differ, both in transportation environments and in operating philosophies. Consequently, the independent purchasing initiatives of these roads are likely to lead to different demands being placed on suppliers. However, the Canadian motive power market is

small, so it is important to identify common or compatible requirements to maximize the economic opportunity for Canadian suppliers.

The options available to locomotive designers are as follows:

(a) truck design and wheel arrangements for all types of locomotives suitable for Canadian mainline operation, including assessment of axle loading, effects on factor of adhesion obtainable with sufficient reliability to provide the basis for train-load computation, first cost, and maintenance cost

(b) transmission systems for all of the above-mentioned types of locomotives, including performance obtainable in terms of factor of adhesion, performance at low speed, first cost, reliability, and cost of maintenance and repair

(c) traction motor and ventilation system design (including ac as well as dc motors), traction motor suspension arrangements, performance (including the effects on load-hauling capability), resistance to adverse environmental factors, first cost, and maintenance, servicing and repair costs

(d) diesel engines, including the use of bottoming cycles, efficiency improvements, turbocharging, horsepower, weight, reliability, first cost, maintenance cost, and the sensitivity of the performance measures to off-spec fuels

(e) developments in alternative fuels distribution (e.g. LNG, coal) and support systems and evaluation of the feasibility of engine modifications if necessary

(f) design of electric/diesel or other hybrid types, covering a range of peak/average power capabilities, including performance characteristics, first cost and maintenance cost

(g) design of coal-fired or gaseous-fueled locomotives, including performance characteristics, first cost and maintenance cost.

The level of adhesion utilization which a locomotive can achieve with sufficient reliability to dispatch trains is already a constraint for diesel-electric locomotives in bulk service and for high-powered electric or turbine locomotives in all applications. Adhesion performance has

advanced from 18 per cent for the SD40, to 22 per cent for units with CN's "positrack" system, and 24 per cent for the GM SD50 with creep control (a level approaching present electric locomotives). Further increases may be possible but could be increasingly deleterious to wheel and rail from a wear and failure viewpoint, unless wheel diameters are increased or improved wheel metallurgy is developed to change the basic creep force mechanism.

A detailed evaluation of the opportunities for higher adhesion should be undertaken by the industry in anticipation of the next generation of locomotives. This would include an assessment of the effectiveness of feedback/slip-control systems for synchronous and asynchronous ac motors, and for series and shunt dc motors. It would also involve screening new wheel alloys with potentially high adhesive properties. Also, the relative performance of various rail treatments would be assessed in comparison with sanding.

Freight Cars. The purchasing cycle for freight cars bottomed out recently as railway operations tracked the recession. When this depressed demand cycle is combined with the improved utilization of existing fleets, it is evident that a shake-out of freight car manufacturers is in progress. Volume purchases of traditional car designs will not occur as in the past. However, railway demands for specialized equipment for bulk and intermodal freight are increasing.

The market is looking for specialized equipment to carry more freight per car with lower maintenance and operating costs.

Special equipment:		
perishable goods	-	refrigerator cars
bulk	-	hoppers, gondolas
international	-	containers
flexibility	-	intermodal
fluids	-	tank
Capacity improvements:		
tare weight reduction	-	aluminum, fibreglass
cube increases	-	double stack containers
Operating cost reductions:		
pure intermodal	-	CN Laser service
unit trains	-	coal service
aerodynamics	-	under study

Service improvements:		
speed	-	advanced braking and coupling
reliability	-	improved maintenance records and control

The market need for special equipment implies higher first-order costs all around. Product development will be more expensive and volumes will be smaller; hence, the market will be further segmented into premium product niches.

Control Systems

Improving the utilization of railway assets can reduce the need for additional investment in line capacity, fleet equipment and personnel to manage the operation. The railways' information needs are as diverse as the applications, ranging through simple information management systems, real-time simulation and control, and sophisticated decision support systems to aid in planning and evaluation. Many different "control" systems have evolved to meet these information needs.

Both Canadian railways have concentrated development efforts on dispatching systems, recognizing the importance of knowing "what's out there" and "where it's going." As information flows improve, the dispatcher is given computer decision models that allow fast assessment of options for train movement. Integration with neighbouring dispatchers leads to real-time system control.

Locomotive on-board systems are required to concentrate and display information developed by various monitoring devices now on the market. Enhancing the engineer's awareness and ability to respond to train performance requirements through use of on-board processors facilitates data acquisition for unit or fleet evaluation. The locomotive on-board system will be a key element of the ATCS.

Yard management has long been a focus for improving efficiency, with the result that development of applicable control systems is well advanced. CN has several sophisticated simulation systems that are used to plan new yards or improvements to existing yards through the ability to test various configurations or train movements. The models are also a useful training tool for both experienced employees and

trainees. Full automation of yards will require control system development and testing.

The signalling system is key for railway control, since it provides two-way communication between system managers and trains. The current method is through train detection by track circuits and control information through the visual indications of wayside signals. To overcome the limitations of this system, several (usually incompatible) approaches for train movement monitoring and the transmission of instructions to the train have been developed. The AAR and the RAC have recognized the undesirable effects of the development of many incompatible control systems. The Advanced Train Control project has as its objective the accelerated commercialization of railway control equipment with standard interfaces. The ATCS will require an array of supporting technology to enable functions now partially provided by track circuits and manual intervention.

Track integrity monitoring, train longitudinal dynamics, remote switch control and verification are examples of problems requiring innovative R&D.

Maintenance

The maintenance of railway systems goes beyond simple track misalignment correction or wheel change-out. Research into the timing and productivity of these and other activities has focussed attention on improving the effectiveness and efficiency of maintenance.

Special-purpose equipment has improved crew performance in the field, yielding productivity gains and reducing interference with train operations. Machine development will continue, as ongoing research identifies the track parameters which have the most impact on system performance and the best ways of maintaining appropriate standards.

This same research enables closer control and evaluation of the timing for track maintenance or replacement, allowing system capabilities to be better matched to the demands of traffic. The optimum sequencing of maintenance operations on major track components remains difficult to attain.

The high sensitivity of capital costs to fleet availability is a convincing reason for R&D aimed at reducing routine maintenance.

2.2.2 Project Opportunities

Opportunities for improvement of rail freight system productivity are basic to a number of actual or potential mega-projects:

- High-Productivity Integral Train (HPIT)
- Advanced Train Control System (ATCS)
- CN/CP Western Expansion
- Electrification
- Natural Resource Transportation

High-Productivity Integral Train (HPIT)

The growth in rolling stock is due almost entirely to the demand for specialized equipment for commodities (bulk, refrigerated goods, tank cars, etc.) and for intermodal equipment. The push for more cost-efficient rolling stock for special service is encouraging railways and the large private fleet owners to specify and purchase innovative designs.

The essence of this trend is embodied in the AAR-sponsored High-Productivity Integral Train (HPIT) program. The aim is to create industry standards for the next generation of rolling stock by focussing railway needs and industry capabilities on a single program. The AAR market projections are enormous (Table 2) and have been the subject of some dispute. Nevertheless, the market is trying to organize itself to lead industry product development. Canadian leadership has been assumed by UTDC R&D, but it is yet to be seen how the majority of Canadian manufacturers will participate in the concept generation and testing.

TABLE 2

HPIT MARKET PROJECTIONS

	Market Demand	Estimated Value
1986	- 30 trainsets - intermodal - 300 trainsets - bulk	$ 7 billion
1995	- 500 trainsets - intermodal - 1,400 trainsets - bulk	$40 billion

Advanced Train Control System (ATCS)

The AAR and RAC are jointly coordinating the development of industry standards for advanced train control systems. Beginning with a comprehensive needs analysis, standards will be set for interfaces between the discrete electronic "black boxes" that will perform various control functions.

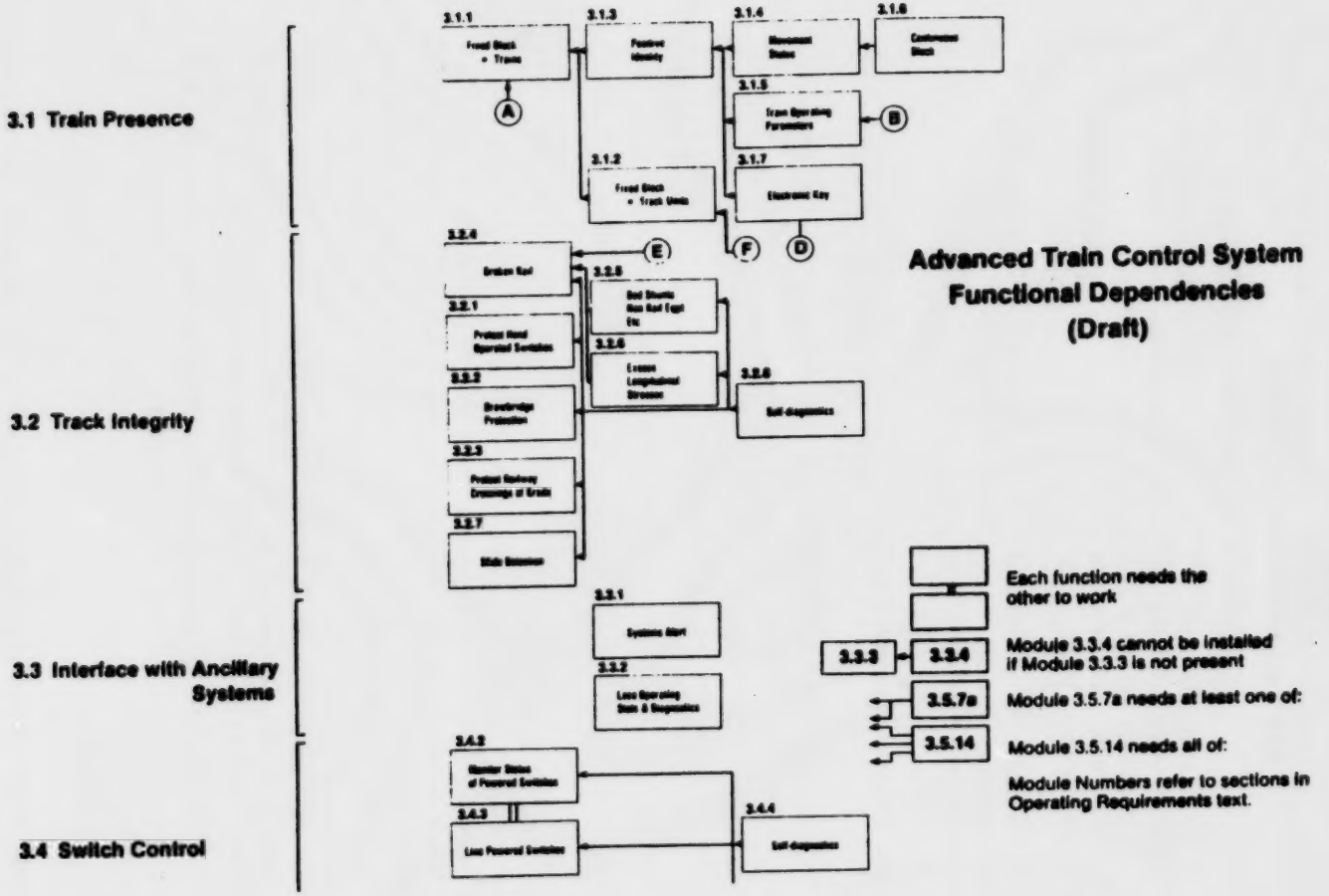
The key elements of the ATCS are:

- detection of train presence
- monitoring of track integrity
- systems interface
- switch control
- train control
- operations management.

The preliminary architecture is presented in Figure 6. The systems engineering team will be composed of ARINC Research, Transportation and Distribution Associates, Inc., and Philip A. Lapp Ltd, a U.S./ Canadian team that blends extensive systems engineering expertise and railway experience.

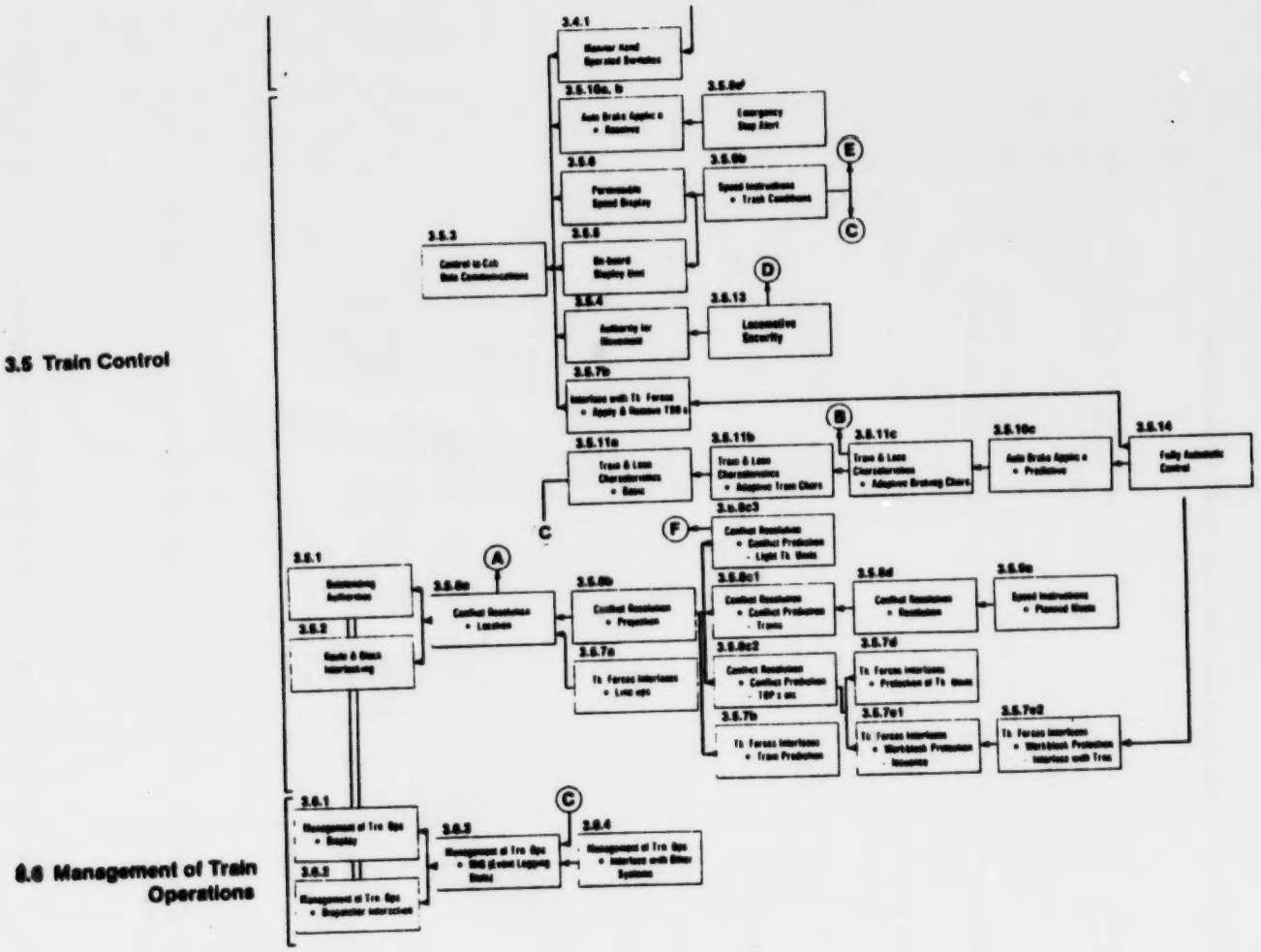
CN/CP Western Expansion

Changes in the Crow Rate legislation have led CN and CP to commit over half a billion dollars a year to upgrading of western capacity. Increases in spending to this level have prompted the federal government and the railways to sponsor purchasing seminars where


3.1 Train Presence
3.2 Track Integrity
3.3 Interface with Ancillary Systems
3.4 Switch Control
Advanced Train Control System
Functional Dependencies
(Draft)
Each function needs the other to work
Module 3.3.4 cannot be installed if Module 3.3.3 is not present
Module 3.5.7a needs at least one of:
Module 3.5.14 needs all of:
Module Numbers refer to sections in Operating Requirements text.

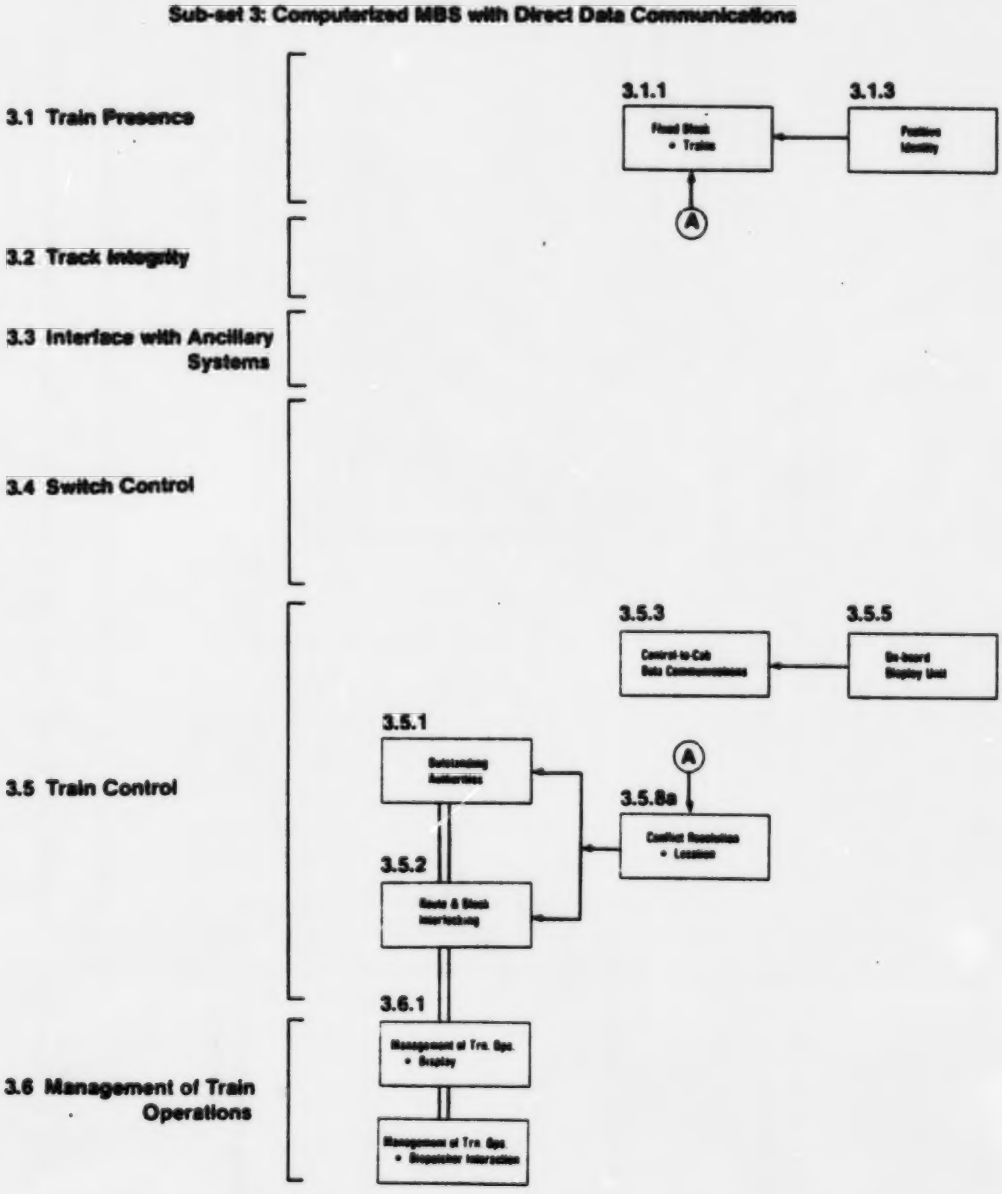
Source: RAC and AAR, "ATCS Operations Requirement," April 1984.

Figure 6 Advanced Train Control system functional dependencies (draft)



Source: RAC and AAR, "ATCS Operations Requirement," April 1984.

Figure 6 (Cont'd) Advanced Train Control system functional dependencies (draft)

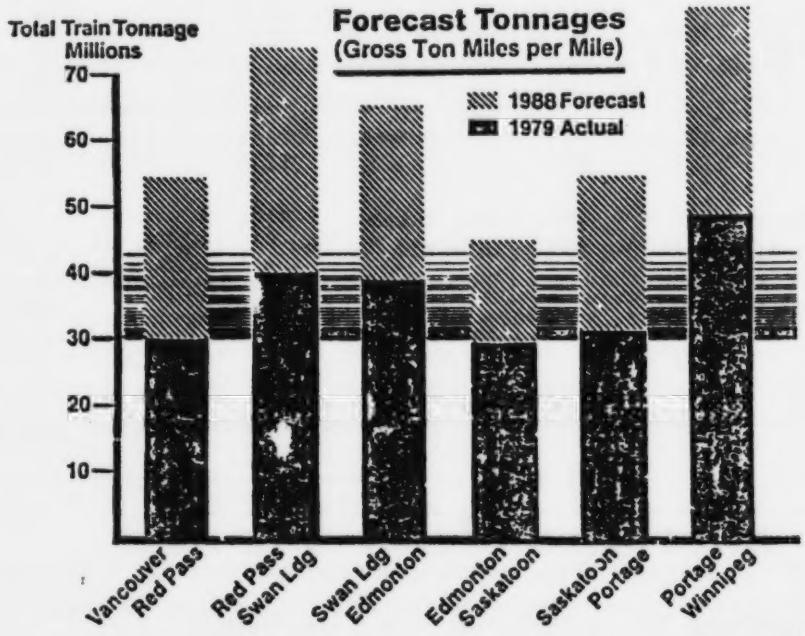


Source: RAC and AAR, "ATCS Operations Requirement," April 1984.

Figure 6 (Cont'd) Advanced Train Control system functional dependencies (draft)

railroad requirements and procedures are presented to potential suppliers. The increase in purchases of conventional materials will likely lure new suppliers from the local (western) ranks. There will still be substantial purchasing in eastern Canada of equipment not available elsewhere: rails, locomotives, cars, etc.

The need for such expansion has been promoted by the railways using statistics such as those presented in Figure 7, where CN's projected western traffic is shown to be at the limits of capacity. The 1984 programs detailed in Table 3 have been matched by 1985 expenditures of over two billion dollars. More detail on CN and CP programs will be provided later in this report.



Source: CN Rail

Figure 7 Forecast tonnages (gross tonne-miles per mile)

TABLE 3

CN/CP - 1984 CAPITAL AND REGULAR SPENDING
($ millions)

	Canadian National	Canadian Pacific	
		West	East
Rails	(1)	$81(2)	(3)
Ties	$135(4)	$18(5)	(6)
Ballast	n/a	$16(7)	45(8)
Bridges	$9	$10	n/a
Facilities	$13	$27	15
Signalling	$39	$21	4
Intermodal	n/a	$9	4
Rogers Pass	--	$65	--
Other		$28	7
	$650	$275	$75
System Equipment (locos, cars, etc.)	$80 - GM, Bomb. $33 - Internal	$100	
Regular maintenance		$390	$340
		765	415
1984 Total	$1,400	----------$1,180----------	

(1) 105 km planned for track renewal
(2) 423 km
(3) 215 km
(4) 3,300,000 ties for replacement, new construction
(5) 755,000 ties
(6) 630,000 ties
(7) 629 km of ballast renewal or new construction
(8) 167 km

Electrification

The case for electrification has been reinforced by experience gained from the BCR Tumbler Ridge Branch Line construction. Ongoing refinement of the total costs and demonstration of operating benefits should lead to more confident cost-benefit analyses. Industrial impacts of electrification have been predicted as in Table 4 and most recently by the DRI/CIGGT report on the national economic impact of railway electrification.[2] On the basis of electrification of CN and CP western networks, it was estimated that Canadian manufacturing firms could expect a $400 to $500 million market over the implementation period.

Resource-Oriented Projects

Besides being a test bed for electrification, Tumbler Ridge is an example of the type of new construction that predominates in North America. It is a single-purpose line of finite life expectancy, built as a profit centre and linked to a natural resource operation in a frontier location.

While the bulk of the investment in these new lines is civil construction, there are instances where systems are expanded in large segments. The accompanying need for locomotives, cars and other equipment frequently spurs the development of specialty equipment and control systems. The only automated railways in North America have been mining-based operations.

2.2.4 Industry Status Report

The discussion of the industry's position with respect to the opportunities available will begin with some major firms. Their capabilities and plans to address these opportunities are critical, since there would be significant economic effects from increases in their business.

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2 "The National Economic Impact of Railway Electrification," W.F. Empy and J.A. Osten (DRI), G.W. English and C. Schwier (CIGGT), F.W.A. Bliemel (Queen's University), May 1983. TP 4461-E

TABLE 4

ELECTRIFICATION

If $10 million spent on industrial electrical equipment in any of these provinces:	B.C.	Alberta	Ontario	Quebec
. Total gross production will increase in these provinces ($millions):				
Ontario	20.8	24.3	27.0	20.7
Quebec	4.2	5.6	5.0	13.0
B.C.	8.1	1.3	.3	.2
Alberta	.2	2.4	.5	.6
Manitoba/Saskatchewan	.9	1.4	.8	.7
Total Canada	35.4	35.3	33.9	35.6
. Total employment will increase in these provinces by (man-years) (biased high):				
Ontario	309	361	405	306
Quebec	61	83	73	207
British Columbia	131	21	4	3
Alberta	12	41	4	4
Manitoba/Saskatchewan	12	20	10	7
Total Canada	530	530	499	535

Source: StatCan input/output runs done for Electrical and Electronic Manufacturers Association of Canada, September 1981

ABEX Industries Limited, Niagara Falls

ABEX is the largest Canadian non-railroad manufacturer of switches. The Niagara Falls facility assembles and warehouses switch materials and composition brake shoes. This plant is one of a network of divisions of ABEX Industries Ltd of Montreal. A foundry in Joliette, Quebec, casts manganese frogs for turnouts as part of a line of wear-resistant products for various industries.

The American parent company is part of the large Illinois Central group and has a diversified railroad product portfolio, all of which can be channelled into Canada through the subsidiary.

ABEX's pre-eminent position in the switch market is being challenged by a B.C. supplier. Nortrak is an offshoot of A&B Rail Contractors and has an agreement with ESCO to produce the manganese castings for frogs. These castings have proved to be a competitive edge for Nortak as they have been reported to be of high quality. The western expansion places local suppliers in a favourable position, so it is unlikely that ABEX will benefit from the increased activity of CN or CP.

Algoma Steel Corp.

Domestic rail production is historically split between Algoma and Sydney Steel Corp. The need for premium rails for severe service has prompted the railways to test foreign products. (There is strong pressure for the railways to buy domestically -- CP from its sister company, Algoma, and CN from Sydney.) Sydney Steel has yet to establish a direction for premium product development, and thus stands to be excluded from the growing premium rail market. Algoma has responded by developing chromium alloyed rails and, more recently, controlled-cooled rails, to compete with offshore suppliers.

Plant modernization to produce the harder controlled-cooled rails is under way. Algoma's ability to produce a consistent high-quality rail will be enhanced and should ensure its position in the domestic market.

Barrie Welding and Machinery Ltd

This privately owned firm has quietly practised some successful niche marketing. It has developed and sold a line of hydraulically driven railway maintenance vehicles very similar in design to a concept developed by the railways and CIGGT in the mid-seventies. Working with the close advice of first Ontario Northland Railway, then CN officials, the experience has given the firm confidence to consider other, more complex special-purpose maintenance machines.

Canadian General Electric (CGE)

CGE's traction products business is directly linked to Bombardier's success in selling locomotives. Recently this has meant that the prime contract has been LRC orders. Bombardier's freight locomotive business is questionable and does not bode well for CGE subcontract work.

The technological expertise at CGE is in danger of being lost. The U.S. parent company has been less than cooperative with any Canadian development initiatives, perhaps through preoccupation with its competitive stance in the U.S. locomotive market. CGE's potential role in aiding HPIT development or next-generation locomotives is unclear.

Canron Inc.

The two product areas that Canron maintains for railroad business are distinctly different in competitive capabilities and relative health. The foundry division produces cast-iron brake shoes as a minority product line. The cast-iron shoe is recognized to be an obsolete technology, supplanted by composition shoes, and ordered only as replacements on older cars that specifically require them. Their marketing has been handled for the last ten years by ABEX, who themselves are major manufacturers of brake shoes.

In contrast, the Tamper division holds the dominant position in the North American maintenance equipment market. Innovative product development is backed up by manufacturing cost reduction programs and diversification into contracting services. International contracts have provided product ideas that are being profitably adapted for

domestic markets. While the main plants are in the U.S., the Toronto group has autonomy to pursue product development and is expanding their Eastern Avenue (Toronto) facility. The Tamper division is ideally situated to exploit railway expansion needs for maintenance equipment and the growing recognition of the benefits of higher track quality standards.

Dominion Foundry and Steel Co. (Dofasco)

Dofasco has the size, financial strength and technical capabilities to be a major development resource in the railway truck market. Its continued participation in the violently cyclical freight car market is to some extent guaranteed, since it owns National Steel Car Ltd, and CN and CP split truck orders between Hawker Siddeley Canada Inc. and National Steel Car as a matter of policy. In the lower-volume but somewhat more sophisticated passenger and locomotive market, Dofasco is virtually the sole supplier of all Canadian locomotive trucks and has had a significant portion of the passenger market through LRC orders.

The demand for higher-productivity trains will entail analysis of truck design to lessen rolling resistance, improve dynamic performance, and reduce dead weight. If a high-speed Canadian passenger system is seriously envisaged, custom truck design will be required. Dofasco has the capital resources to be a major participant. As a Canadian firm, maximum benefits can be derived from Dofasco becoming a factor in North American and export markets.

General Motors Diesel Division (GMD)

The Canadian subsidiary of the Electro Motive Division of General Motors (U.S.) has established itself as the preferred locomotive builder in Canada. It has added significant export business to this base, shipping all over the world, excluding the U.S. Their most recent development was the adaptation of ASEA electrical technology to create the Tumbler Ridge locomotive. GMD will manufacture the new SD60 series locomotives for the Canadian market. The major improvements to these units are in the on-board auxiliary systems that make use of micro-processor electronics to monitor and fine-tune engine speed and tractive and braking effort. Further "black boxes" are expected for the locomotive.

These products provide the London plant with some engineering freedom and it has increased its capabilities by implementing a sophisticated CAD/CAM system. The Canadian facility will continue to effectively serve the domestic market, using it as a base to pursue export orders.

Kershaw Manufacturing Canada Ltd

Kershaw recently opened a branch plant with a limited product mandate. Although basically an assembly shop, the Cornwall, Ontario, facility has recently begun to entertain ideas for product development. It stands to be a competitive factor in a Tamper-dominated market. As railway concern for maintenance efficiency and effectiveness grows, Kershaw will be in a position to develop custom equipment in Canada for the Canadian market.

National Steel Car Ltd

The only freight car manufacturer in Canada that has not diversified against cyclical railway purchasing swings owes some of its durability to its parentage (Dofasco) and location.

Reluctant to initiate product development without CN or CP sponsorship, National has limited its innovation to minor introductions of automated manufacturing methods.

NYAB-VICOM

New York Air Brake, a division of General Railway Signal Co., has challenged WABCO's dominance of the freight car brake market and appears to be making large gains. Aided somewhat by the railways' discomfort with monopolistic supply, NYAB has succeeded through aggressive marketing and proven product integrity. The Canadian facility is self-supporting and represents a significant resource for future car component development, both mechanical and electrical.

NYAB-VICOM's marketing strategy in the international aerospace business offers some encouragement that it may act similarly in the railway field.

Procor Ltd

Procor's prominence worldwide as a lessor of specialty cars is based on its willingness and capability to respond to customer needs with high-quality, competitive equipment. At its relatively modest facility in Oakville, Procor manufactures and rebuilds a wide variety of cars. Sophisticated information systems allow managers to identify high costs in car operation and maintenance. Continuing development is directed toward assuring customers that Procor cars are competitive in the market.

Procor's knowledge and management approach would prove a useful combination for HPIT development or hazardous goods R&D.

Steel Company of Canada, Inc. (Stelco)

Stelco's significant share of the conventional track hardware market will be eroded by the increasing use of specialty fasteners in novel track construction. There are no Canadian designs in this growing market but there could be if Stelco applied a small portion of its resources to design innovation.

Glenayre Electronics Ltd

Glenayre has been a significant developer of electronic systems for railways. The BCR-LIC development is in the field-testing phase. Reconfiguration of the system to meet general industry requirements is indicated but will be expensive.

The ACI car identification system has some competitive characteristics that also require field demonstration in order to prove its reliability.

The End-of-Train Unit (ETU) monitoring system has been very successful and has been ordered in quantity by two major U.S. railroads.

Glenayre is focussing on the commercialization of the above systems. There are no plans to develop further unrelated products at this time. Glenayre recently concluded an agreement to transfer its transportation product line to Dynamic Services Ltd (DSL) of Montreal under an

exclusive license. DSL will market LIC, ETU and ACI systems manufactured by Glenayre.

Bombardier, Inc.

Development activity at Bombardier included several programs in power plant design, switcher locomotive design, locomotive trucks and hybrid locomotives. Internal programs were under way to:

- improve component reliability
- develop on-board electronics
- develop fabricated trucks.

Reluctance, however, on the part of the domestic market to commit to buy current Bombardier locomotives is threatening the potential for the products under development. "Go/no go" decision points have been reached on some programs. Restructuring or termination of selected projects will depend on whether the program participants decide that Bombardier is:

- an integrated locomotive builder
- a locomotive assembler
- a locomotive parts manufacturer, or
- not in the locomotive business.

Hawker Siddeley Canada Ltd

The various divisions of Hawker Siddeley (HS) -- Canadian Steel Wheel, Canadian Steel Foundries, and the Trenton Car Works -- all take advantage of the HS research and development group. Its most recent accomplishment was supported by the IRAP program and led to the current production of stress-reducing S-plate forged wheels. These unique designs were developed over three-and-a-half years, requiring the creation of analytical programs to simulate plate stresses for the various design alternatives.

Capabilities exist in truck design and CAD. The company is quietly innovative, favouring development programs that create expertise available for exploitation by its many divisions and subsidiaries.

Summary

The Canadian rail supply sector is highly diverse, offering a wide range of skills with which to address product opportunities. The current low mobilization of these resources reflects the nature of the railway/supplier relationships and the recent recessions. There has been little investment in R&D for product development or plant improvements.

Within Canada there are examples of virtually every known operating condition for conventional rail or transit. The opportunity exists for our rail systems to be the showcase for manufacturing capability, providing the home base from which to market to the world.

Fundamental to strategy formulation is the matching of capabilities to opportunities. In the preceding pages we have shown that the manufacturing base for the Canadian rail supply industry has appropriate skill resources. Business opportunities, many of which involve product groupings with export potential to the U.S. and abroad, are possible within Canada. There is a lack of enthusiasm, however, in the supply sector. Traditional marketing practices, uncertainty concerning long-term product needs for the railways, a lack of investment in plant modernization, and recent recessions in the industry have left us a risk-averse supply sector with over-capacity in the declining technologies.

The intimidating gap between idea generation and customer acceptance has prevented the industry from considering large-scale innovation. Incremental improvements to standard products that represent little technological risk are much easier to sell to a conservative market. The market is not configured to reward risk-taking, particularly in technologies that involve more than one operating department within the user's organizational structure. The reluctance to economically and independently bridge the gap, by investigating development feasibility at each step, forces firms to restrain development until railroad acceptance is solid enough to commit the large amounts of resources needed to demonstrate the product.

Government intervention and/or procurement policies have been well-employed in the past, generating significant benefits. The governments

assumed a proportion of the risk and cost. However, comments were received on how significant development opportunities were not taken advantage of during the series of Canadian Wheat Board car orders. These lapses were attributed in large measure to the product approval and acceptance processes of the railway industry.

A change in industry relationships is needed to provide a structure that is receptive to change, and demanding of the types of innovation needed to create effective, efficient transportation. Full definition knowledge of system requirements will allow manufacturers to create the products needed. Long-range procurement policies will reduce the risks they face while developing their products. Development risk must be mitigated in actuality and in the minds of the decision-makers.

2.2.4 Railway Financial Summary

The rail freight industry in Canada generates $6 billion in revenues (1983 levels, see Table 5), on an asset base of $9 billion. Net income for rail freight operations was on the order of $400 million.

In 1983, the railways moved 232 billion tonne-km of freight (263 million tonnes), over a network of some 38,000 km of line. Employment in the industry is 82,000.

The Canadian system in 1983 moved about 15 per cent of the level of traffic that the U.S. system moved, but produced net revenues 68 per cent of the U.S. level. U.S. performance in 1984 improved somewhat following extensive merger activity and the consequent consolidation and divestiture activities. U.S. maintenance programs were redirected towards the strengthening of the merged network and are thought to have been at lower levels than in 1983.

In comparison to the U.S. system, the Canadian rail freight industry is dominated by two transcontinental carriers which account for more than 90 per cent of the sector. There are a few smaller regional or special-purpose companies, plus a number of very small carriers.

TABLE 5

CURRENT CANADIAN RAILWAY FREIGHT INDUSTRY ENVIRONMENT
(millions of dollars)

	CN/CP	Other	Total
Revenues, Total	5,832	571	6,043
Freight	4,807	479	5,286
Passenger	384*	37	421
Government payments	504	30	534
Other	137	25	162
Expenses, Total	5,265	551	5,816
Fixed plant maintenance & dep'n	894	142	1,036
Equipment maintenance & dep'n	1,321	124	1,445
Operations	1,829	170	1,999
Administration	971	102	1,073
Other	251	13	264
Net non-rail expenses	2	4	6
Income tax provision	179	10	189
Net income	385	10**	395
Total assets	7,539	1,847	9,385
Employees	80,864	1,065	81,929
Kilometres of track	30,708	7,564	38,272
Freight tonne-km (billions)	213.1	18.8	231.9

* VIA Rail Canada, Inc. payments to CN/CP for train service.
** Includes $4 million extrordinary item taken into income.

Source: StatCan 52-215

2.3 Railway Technological Requirements

Identifying specific technological requirements of the railways for the short and medium term is not an easy task. It is much easier to come up with a problem statement or performance requirement. Various technologies could be applied in response, but will have differing degrees of feasibility and cost. An ideal technology application will have a low life-cycle cost, be easy to implement, not require retraining of existing staff or hiring of new staff, have multiple sources of supply, and, of course, eliminate the problem entirely or achieve maximum improvements. Most applications involve compromise on some critiera, adding complexity to the investment or implementation decision.

When the railways are considering a set of technological solutions, the natural tendency is to factor unfamiliar technologies by a value corresponding to the perceived risk associated with their assimilation. Consequently, while asking for or researching technological requirements, short-term needs are constrained to be conventional, while longer-term possibilities are allowed to be more speculative. For the purposes of this analysis, the longer-term requirements will be identified as technologies where further basic understanding is needed before applications can be made. The key criterion in investigating the longer-term development requirement will be that the current set of technologies cannot cope with the situation and that there are no readily available applied technologies.

Short term:

- machine control systems:
  - maintenance equipment -- field and shop
  - locomotives
- information processing systems:
  - network control
  - management control
- freight car design:
  - specialty trucks
  - couplers
  - structure

- track improvements:
  - concrete/steel/composite ties
  - specialty fasteners
  - wheel/rail profile control

- safety:
  - dangerous situation monitoring:
    - hot box detection
    - on-board monitors
  - end-of-train units

- communications:
  - data reliability
  - transmission speed

Medium term:

- system management:
  - network control schemes
  - ATCS

- track design:
  - wheel/rail interaction improvement
    - reduced wear, fatigue
  - construction/maintenance techniques

- motive power:
  - alternatives to reinvestment in diesel
  - improved adhesion, braking

Another way of considering railway technological requirements is to say that short-term needs can be resolved through substitution of a superior component technology to enhance the performance of a larger system, while longer-term needs may involve a rethinking of methods and the system in order to effectively use a new technology. For example, electronics replacing relays is short term, while designing the ATCS is longer term. The management of large-order change will require the railways to consider organizational reform as well as technological change. The ability of the railways to adapt will influence the speed at which new technologies are implemented.

2.4 Economic Forecasts (Task 5.6)

2.4.1 Energy, Mines and Resources Canada

An economic scenario developed by Energy, Mines and Resources Canada[3] is summarized in Table 6. Steady economic growth to the end of the century was predicted, with the railway share of RDP increasing at a rate higher than the average for the economy as a whole. Among the key features of this forecast were:

- continuation of "high" interest rates in the medium term
- continuation of the current unemployment rates until the 1990s
- holding the line on inflation at the four to five per cent level
- slowly increasing population, with a much greater increase in new car sales (there is nothing on construction)
- rebound in certain industrial sectors, particularly iron and steel.

One important implication of this document was energy costs. Diesel fuel prices were forecast to increase in the near term at less than the rate of inflation. The real price of diesel fuel was expected to decrease until the early 1990s and then increase, but with the year-2000 real price being only marginally higher than current levels. If this forecast holds, the trend over the 1970s of the energy component of the railway cost structure doubling from four/five per cent to ten per cent would be arrested, thus reducing the priority for energy saving initiatives. Steady or slightly declining energy prices also imply that there would be less pressure for a shift from highway to rail for certain commodities.

At the same time, electricity prices were forecast to increase in real terms over the near term, with no decline taking effect in the early

3 "Long-Term Energy Supply/Demand Outlook," Energy, Mines and Resources Canada, Spring 1984.

1990s. However, by the year 1995, electricity prices for industrial use were forecast to have declined in real terms to 90 per cent of the 1984 levels. This would have implications for railway electrification. There would be obvious resistance to conversion at a time when the diesel fuel price is declining in real terms and electricity prices are increasing. In 1984, the ratio of diesel fuel prices (per litre) to electricity prices (per kWh) was 14.7. It was expected to decrease to 13.5 by 1987, but increase to 17.2 by the year 2000.

The continuation of the high costs of money forecast in this scenario means that better productivity would be required from investments. This applies equally to expenditures on new assets and expenditures to replace existing assets. It also gives more incentive to get better productivity -- in terms of utilization -- out of existing assets to meet the needs of increased traffic.

There was little in this economic scenario which bore directly on the traffic the railways would be expected to carry. Some of the growth in the rail RDP represented a recovery from the traffic downturn. There was, however, a requirement to handle new traffic, by as much as three per cent per year over the next ten years, if the increased rail RDP were to be translated directly to tonnages. The forecast of rail diesel fuel demand showed a similar increase. With the growth in iron and steel and in automobile sales -- both of which use rail extensively -- it could be assumed that handlings in the southwestern Ontario area would account for some of the railway growth.

Update

An update of the forecast was produced by EMR in the fall of 1984 which recognized changes in oil producibility, the declining value of the Canadian dollar (with respect to the U.S. dollar), and other events.

The basic trends in the economic forecast remained unchanged. For example, rail diesel fuel demand by the year 2000 was only one-half of a per cent lower than the spring forecast. The major differences were in energy prices for diesel fuel -- the decline in real price to the mid-1990s was not as pronounced and the rebound in prices was stronger, with the year 2000 price being 7.5 per cent higher than that in 1984. For electricity, the near-term increase in real prices was not

TABLE 6: ECONOMIC ASSUMPTIONS/ENERGY PRICES, EMR SPRING 1984 FORECAST

		FORECAST 1981	1982	1983	1984	1985	1986	1987	1990	1995	2000
	OUTPUT AND INCOME: ($1971B)										
GNPK	GROSS NAT'L EXPENDITURE (NAT'L)	136.114	130.069	133.971	140.723	145.367	148.841	153.812	168.593	195.990	225.266
RDPC	RDP - TOTAL	121.161	115.524	118.193	123.973	127.840	130.589	134.820	147.060	172.042	197.887
RDPAGC	- AGRICULTURE	3.158	3.246	3.306	3.491	3.550	3.607	3.683	4.083	4.850	5.682
RDPINC	- INDUSTRIAL	37.757	33.231	34.749	37.210	38.385	38.973	40.734	45.594	55.491	64.667
RDPIRC	- IRON & STEEL (NAT'L)	0.991	0.781	0.843	0.925	0.968	0.971	1.052	1.197	1.505	1.788
RDPCPC	- COMMERCIAL & PUBLIC ADMIN	63.172	62.506	63.219	65.381	67.414	69.066	70.903	76.347	87.004	98.235
RDPAVC	- AVIATION (NAT'L)	1.611	1.512	1.447	1.521	1.601	1.678	1.735	1.891	2.244	2.636
RDPRLC	- RAIL (NAT'L)	1.963	1.700	1.802	1.964	2.087	2.172	2.253	2.358	2.813	3.289
RDPPCC	RDP PER CAPITA	5.000	4.717	4.756	4.942	5.050	5.114	5.235	5.578	6.315	7.027
YPDKC	REAL PERSONAL DISPOSABLE INCOME	99.674	98.799	97.119	97.896	101.792	104.887	108.841	119.499	138.379	157.911
YPDPCC	PERS'L DISP. INCOME PER CAPITA	4.897	4.813	3.908	3.903	4.021	4.107	4.226	4.533	5.000	5.630
	PRICES AND COSTS: (1971=1.0)										
PWPIUS	U.S. WPI (1967=100.0)	293.4	299.3	304.2	316.4	329.1	342.2	355.9	400.4	487.1	592.6
PGDP	GDP DEFLATOR - TOTAL	2.548	2.663	2.782	2.926	3.058	3.180	3.308	3.721	4.527	5.508
PGDPAG	- AGRICULTURAL	3.224	3.362	3.463	3.643	3.807	3.959	4.110	4.632	5.635	6.856
PGDPIN	- INDUSTRIAL	2.691	2.855	3.116	3.279	3.426	3.563	3.706	4.168	5.071	6.170
PGDPCP	- COMMERCIAL	2.584	2.780	2.942	3.096	3.235	3.364	3.499	3.936	4.788	5.826
PCXDE	PERS. CONS. DEFLATOR EX. ENERGY	2.282	2.513	2.663	2.802	2.928	3.045	3.167	3.562	4.334	5.273
CPI	CONSUMER PRICE INDEX	2.369	2.625	2.772	2.916	3.047	3.169	3.296	3.707	4.510	5.487
PFX	EXCHANGE RATE ($CDN/$US)	1.199	1.234	1.235	1.235	1.235	1.235	1.235	1.235	1.235	1.235
RIPMVB	AVG. YIELD - 10 PROV'L BONDS	15.9	15.4	12.5	12.9	12.8	11.3	10.4	9.6	8.8	7.1
	DEMOGRAPHIC: ('000)										
POPC	TOTAL POPULATION	24330.	24620.	24854.	25085.	25313.	25536.	25753.	26363.	27242.	28046.
HHC	TOTAL HOUSEHOLDS	8026.	8254.	8394.	8526.	8651.	8768.	8880.	9184.	9620.	10031.
RHHSTC	SINGLE / MULTIPLE HOUSEHOLDS	0.673	0.670	0.668	0.668	0.667	0.668	0.669	0.669	0.670	0.671
	LABOUR FORCE: ('000)										
POPLFC	LABOUR FORCE SOURCE POPULATION.	18375.	18664.	18917.	19141.	19357.	19566.	19767.	20342.	21234.	22115.
LFC	LABOUR FORCE	11904.	11958.	12183.	12415.	12651.	12878.	13064.	13641.	14535.	15392.
EMPC	TOTAL EMPLOYMENT	11006.	10644.	10734.	11004.	11197.	11338.	11491.	11995.	13015.	14101.
URATEC	UNEMPLOYMENT RATE (%)	7.55	10.99	11.89	11.37	11.49	11.95	12.04	12.07	10.46	8.38
	PASSENGER VEHICLES:										
NPVSTC	SALES - VOLUME ('000)	904.2	713.5	843.1	1000.0	1011.0	1041.3	1095.5	1287.4	1384.8	1560.6
ENPVS	- EFFICIENCY (L/100KM)	11.2	10.0	10.0	10.0	10.5	10.8	11.2	11.2	11.2	11.2
KTPVSC	STOCK - VOLUME ('000)	9428.5	9298.3	9267.1	9371.8	9476.0	9598.7	9766.4	10502.6	12183.2	14015.5
EKTPVC	- EFFICIENCY (L/100KM)	15.0	14.3	13.5	12.8	12.2	11.8	11.5	11.2	11.2	11.2
KTMAC	MANUFAC'NG CAPITAL STOCK ($71B)	41.642	43.509	45.110	46.878	48.758	50.679	52.625	59.281	72.597	89.358
KGDSC	NATURAL GAS DIST. CAPACITY (MCM)	761.	808.	812.	815.	823.	830.	841.	868.	916.	950.
DDAYSC	HEATING DEGREE DAYS (NORM=1)	0.946	1.027	0.957	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 6: ECONOMIC ASSUMPTIONS/ENERGY PRICES, EMR SPRING 1984 FORECAST (Cont'd)

		FORECAST 1981	1982	1983	1984	1985	1986	1987	1990	1995	2000
TRANSPORTATION DEMAND - II (PETAJOULES)											
	RAIL TRANSPORTATION:										
HDFRLC	DIESEL FUEL OIL	91.29	82.11	80.93	85.55	88.30	90.02	93.29	102.74	119.77	134.54
HHFRLC	HEAVY FUEL OIL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCCRLC	COAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HELRLC	ELECTRICITY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HOFRTC	OTHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HTSRLC	TOTAL	91.29	83.99	80.93	85.55	88.30	90.02	93.29	102.74	119.77	134.54
ENERGY PRICES - NATURAL UNITS (NOMINAL)											
	PETROLEUM PRODUCTS: (C/LITRE)										
PRLRTC	GASOLINE - ROAD	35.23	42.57	45.72	46.42	47.40	48.36	49.99	55.83	69.87	87.38
PRLRSC	- PROV'L SALES TAX	5.11	7.08	7.75	7.26	7.36	7.47	7.69	8.54	10.70	13.38
PRLBTC	- OFF ROAD (EX. PST)	30.12	35.49	37.98	39.16	40.04	40.89	42.30	47.29	59.17	74.00
PRLFS	- FEDERAL SALES TAX	2.14	2.62	2.82	2.90	3.15	3.20	3.31	3.38	4.32	5.50
PMGFE	- FEDERAL EXCISE TAX	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54
PDFATC	DFO - ROAD	32.10	39.48	42.49	42.54	43.45	44.35	45.92	51.61	65.23	82.29
PDFRSC	- PROV'L SALES TAX	5.55	7.07	7.39	6.93	7.05	7.18	7.42	8.37	10.62	13.47
PDFRLC	- OFF ROAD (EX. PST)	26.36	32.42	34.97	35.51	36.31	37.08	38.41	43.13	54.47	68.63
PDFFS	- FEDERAL SALES TAX	2.03	2.53	2.72	2.80	3.04	3.09	3.20	3.26	4.17	5.31
	ELECTRICITY: (CENTS/KWH)										
PELRAC	- RESIDENTIAL	3.16	3.64	3.96	4.14	4.40	4.64	4.85	5.28	5.69	6.64
PELCPC	- COMMERCIAL	3.76	4.23	4.52	4.80	5.10	5.37	5.61	6.09	6.56	7.63
PELINC	- INDUSTRIAL	2.18	2.46	2.74	2.89	3.07	3.24	3.41	3.69	3.90	4.55

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as strong, nor was the decline in real prices between 1990 and 2000 as strong. The year-2000 ratio of diesel-to-electricity prices was greater in the update -- 17.9 compared to 17.2 in the spring forecast. In addition, the turn-around in the trend of this ratio -- indicating a relative cheapening of electricity -- occured sooner.

2.4.2 Organization for Economic Cooperation and Development (OECD)

The OECD issued a short-term outlook[4] which saw a rebound in the Canadian manufacturing sector in general for 1984, continuing into 1985. No sectoral details were given.

The OECD medium- to long-term outlook focussed on the mineral and forest products industry. Including the basic associated manufacturing activity, these sectors accounted for approximately 15 per cent of Canadian economic activity. They are major export commodities and account for a significant share of Canadian railway tonnage.

While the OECD forecasts a resurgence of demand for forest and mineral products, it cautions that world consumption growth over the next twenty years will be much slower than that over the past twenty years, and that there will be fierce international competition in mineral markets. With slim profit margins, the OECD sees the need for improved productivity throughout the whole resource sector. In the forestry sector, the OECD sees a shift in demand growth from Canada's traditional products -- lumber and pulpwood -- to groundwood specialty products, which the OECD states is "unfavourable for Canada."

As backup for its forecasts of lower growth, the OECD quotes a DRIE resource sector survey which shows "poor" capital spending projections to the late 1990s.

There are two major implications for the railway sector contained in the OECD review. First, long-term traffic growth projections based on increased international sales of resource products must be viewed with caution. Second, there will be increased pressure for productivity

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4 "Review of the Canadian Economy," Organization for Economic Cooperation and Development, Spring 1984.

gains and cost savings. With the "fierce international competition," small profit margins, and a "high" transportation cost component in the final price, even modest productivity gains can have a significant impact on sales.

CN has recognized the same thing that the OECD has noted in the slowdown of resource demand growth. They have lowered some of their traffic forecasts by moving from projections of previous trends to estimation of specific resource projects/movements.

2.5 Near-Term Capital Spending, CN/CP (Task 5.7)

CN and CP together plan to spend nearly $4 billion in 1985 through 1987 on capital projects. Expenditures include normal renewal and replacement of track, increased plant capacity to handle expected increases in western resource traffic, renewal and expansion of motive power and rolling stock, additional intermodal equipment, new and upgraded control and communications systems, and new and expanded equipment maintenance facilities.

CN Rail's projected capital expenditures for the 1983-87 period are $3.16 billion.[5] Approximately 40 per cent is specifically designated as western Canada expansion, while 48 per cent is designated as basic roadway renewal and special projects.

Forecast 1985 expenditures are $626 million,[6] including:

• roadway renewal	$213 million (50 per cent in West)
• increased plant capacity	137 million (mostly in the West)
• added plant for new business	6 million (mostly in the West)
• intermodal facilities	9 million (mostly in the East)
• maintenance facilities	22 million (2/3 in the West)
• other plant, etc.	69 million (split unknown)
• rolling stock	200 million

Motive power expenditures include plans to purchase or rebuild 72 locomotives, re-equip 42 units with positive traction control, and remanufacture 175 traction motors. Twelve hundred and four new freight cars

5 A further $1.5 billion is forecast to be spent in 1988-89.

6 Source: CN 1985 Capital Budget

are being acquired, including 650 covered hoppers for western expansion. A further $28 million is budgeted for rolling stock conversions and additions. In the intermodal field, 260 new 48-foot TOFC trailers and 52 state-of-the-art, low-deck, articulated, five-platform flat-cars are being acquired. In addition, $5 million is being spent on intermodal handling equipment.

CN Rail forecasts (1985 capital budget) an average annual growth in tonnage handled of 2.3 per cent from 1984 to 1989, bringing total tonnage to 135 million, up from 113 million in 1981. The forecast of growth in revenue ton-miles is slightly higher.

On a regional basis, the tonnage growth rate is expected to be slightly lower than the average in central Canada, while growth in the West is expected to be somewhat higher than the average. Of western traffic, a disproportionate share is expected in the Mountain region as opposed to the Prairies.

In terms of commodity groupings, strong growth is expected in fuels and chemicals (4.3 per cent per year -- predominantly western coal, etc.), automobile traffic (4.2 per cent per year), and intermodal traffic (5.3 per cent per year). The latter two categories accounted for only 7.4 per cent of total tons in 1983, but a disproportionately higher percentage of revenues. A decline is expected in non-grain food, construction materials and manufactured goods. (Some of this decline is not a loss of traffic, but a shift to intermodal.)

CP has reported its 1983-87 capital expenditure program to be on the order of $3 billion, representing annual expenditures nearly double that of the early 1980s. Only one-third of this amount is earmarked for the normal replacement/renewal of existing plant and rolling stock. The balance is for new assets to meet expanding railway traffic demands and to provide productivity improvements.

The CP capital expenditure plan is based on "no radical technical changes." All acquisitions are for conventional railway equiment and plant.

The largest single capital project is the new tunnels, bridges and double-tracking in the Rogers Pass area, accounting for 30+ per cent of new spending. Other projected expenditures include:[7]

- $700 million for new locomotives, cars and work equipment
- $100 million for new repair/maintenance facilities (mainly in the West)
- $400 million for improved communications/control systems.

2.6 Resource Development Forecasts (Task 5.8)

2.6.1 Thermal Coal Potential

A 1979 study by Canadian Resourcecon Ltd[8] for the Canadian Energy Research Institute estimates that by 1990 there would be a **potential** demand of 56-65 million tonnes of thermal coal, increasing to 71-95 million tonnes by the year 2000. This demand includes both industrial and utility users. The forecasts are based on a Toronto crude oil price in 1990 of $20/bbl (1978$Cdn), with coal selling at a discount from equivalent oil/gas prices to encourage industrial use.

The Canadian Mining Journal (February 1985 issue) quotes the currently available forecasts of total Canadian consumption of coal in 1984 as being on the order of 50 million tonnes, of which eighty per cent is used by electric utilities. Of the 50 million tonne consumption, perhaps 65 per cent is of domestic origin. Much of the domestically-produced and consumed thermal coal is used in mine-mouth generating stations. Total Canadian production of coal is forecast at 57 million tonnes, with approximately 45 per cent destined for export. Of the total handling of coal in Canada (domestic production plus imports), the railway system moves less than half.

With a current crude oil price in the range of $35/bbl (1978$Cdn), the Canadian Resourcecon study would appear to give rise to substantive increases in coal traffic for the railways. This may not be the case. Certainly the 1984 projections by the Canadian Mining Journal of utility consumption are in the same range as the Canadian Resourcecon study

7 Source: CP Operational Requirements for HPIT

8 "Potential Markets for Thermal Coal in Canada," Canadian Resourcecon Ltd, ISBN 0-920522-03-3.

projections for 1985. The bulk of the increase in utility coal use is in areas where mine-site generation is used. There is some potential for railway haulage of coal to Ontario and B.C. thermal plants -- as much as 20 million tonnes over current traffic by the late 1990s. The increased use of coal in Ontario, however, does not seem to mesh with public statements from Ontario Hydro.

The same forecasts show the potential for 25 million tonnes of coal being used directly by industrial concerns. (We have found little evidence of such conversions being contemplated.) Here there would be good potential for railway traffic; however, the study indicates that coal would need to sell at a discount. Some of this discount would need to take the form of increased rail productivity. In addition, the typical industrial user (with the exception of oil sands plants) would be on a smaller scale, not justifying full trainload lots and high-throughput unloading facilities. Thus, a necessary prerequisite to increased industrial use of thermal coal may be development of means by which the economies of unit trains can be applied to mutli-car-load lots. A situation might be foreseen where coal leaves the mine site and is dispatched to industrial areas in unit trains, with some other method of final delivery.

2.6.2 Ontario Forecast from BILD

An Ontario BILD paper[9] emphasises the importance of transportation to the health of Ontario producers -- mainly resources but also manufactured goods -- with an obvious link of the health of these industries to the health of the Ontario and national economies. The paper emphasizes fuel economy and the need for low-cost, reliable bulk transportation.

There are no specific economic or traffic forecasts in the report or referenced. There is commentary on various key resource sectors.

Forestry. An expansion of the pulpwood industry is foreseen. For the raw material, railway transportation is a large component of the input factor cost. Costs are important since there is considerable competition

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9 "Background Paper on Transportation and Resources," Ontario BILD Program, January 1981.

from other suppliers (especially offshore) for the U.S. market. Much of the output of the industry goes to the U.S. by rail, where again transportation cost is a large part of the final delivered cost. Potential for expansion of hardwood logging in southern Ontario is also foreseen.

Industrial Minerals. Very good potential for the expansion of this industry is foreseen. There have been growing imports of these commodities in past years, which domestic products could replace. From a review of statistics in the CIGGT Transportation Data Base, this type of commodity moves in heavy loads, over short distances.

Mining. Expansion of gold mining is foreseen -- indeed, this trend is common to a number of forecasts and is confirmed by current mining investment activity. Gold and other precious metals do not result in great quanities of product being available to the railways -- the annual output of a large gold mine is only a few tonnes. However, since these mines are in "remote" areas, there is an increased need for community access for supplies, personnel and equipment. One potential role for the rail sector which has not been considered in the past is the short-haul movement of massive amounts of precious-metal-bearing ore from individual mine sites to central reduction plants.

Such a potential is directly identified with respect to other metals. While many ores have economic potential, they are of a sufficiently low grade to make on-site milling and smelting an uneconomic investment. Rather, custom facilities in the mining areas are foreseen as a more attractive investment; one which will allow the development of many of the smaller mineral sites by smaller mining operators. This will require very cost-efficient bulk transportation, but this will not be in areas where the economies of 10,000-tonne unit trains can be exploited. If rail is to be profitably exploited in this type of movement, there will be a need for either intermodal bulk shipping or the development of low-cost branch lines and spurs directly into the mining properties. Another need cited by the BILD paper that impacts on this type of movement is terminal loading/unloading. The specific example used is for bulk lake carriers. This need for rail is equally important if rail is to be used.

3. RESEARCH PRIORITIZATION

3.1 Process

The identification of priority R&D within the mandate of the ARFP required an assessment of the relevance of the program itself four years after its introduction. The preceding pages have reported the discussions, submissions, investigations and speculation necessary to establish system status and perceived needs. As will be shown, current research and development priorities are much the same as in 1981, refined in some areas, still obscure in others, but reinforcing the intent of the ARFP.

A major payoff from the ARFP should be an improvement in the productivity of Canadian railways. This means that the cost of moving goods to market can be accomplished at a lower cost. The potential permeates the industry. A few examples:

Fuel. In 1983 Canadian railways paid $650 million for train fuel, nearly 12 per cent of total operating expenses. This is two-and-a-half times the level of fifteen years ago. Thus, programs which result in, say, a 10 per cent gain in fuel efficiency could return a $65 million per year direct savings plus substantial reduction in fuel tax payments. With traffic growth and increasing fuel prices, this savings will continue to grow. Many strategies can contribute to decreased fuel consumption. Among them:

- more efficient locomotive designs
- improved train handling
- improved train dispatching techniques
- improved freight car truck design
- improved car aerodynamics
- increased car payloads
- reduced car and locomotive weights
- grade reduction and track design changes

Labour. In 1983 the direct labour bill for Canadian railways was $2.7 billion. Benefits and other direct employment-related costs bring the total to $3.2 billion, 57 per cent of operating expenses. Thus even modest gains in labour productivity can provide a high payoff. For example, 10 per cent of the cost of bulk trains is crew. A 10 per cent increase in payload per train gives a 10 per cent increase in crew

productivity. Programs which permit the reduction of crews would substantially increase this productivity. Elimination of one brakeman increases crew productivity by 20 per cent for the whole system. This could be worth $60 million per year. Similarly, programs which improve terminal handling time and promote more efficient train handling and dispatching translate to increased crew productivity, both for over-the-road crews and yard crews. The logical extension of crew productivity -- automated trains and terminals -- could result in an annual savings of $300 million or more at current traffic levels. There are other areas for labour productivity gains. For a one per cent improvement in equipment maintenance and servicing, there is a potential savings of $10 million per year in labour. Such gains could be accomplished through automation of shop and servicing activity, improved rolling stock design and materials, health monitoring, and increased car and locomotive capacity.

Investments. Canadian railways own 3,800 locomotives and 150,000 cars, with a book value of $1.8 billion, a figure which grossly underestimates the replication value of the equipment. In addition, there are many thousand private cars in the system. The aging of the fleet, changes in traffic mix, and projected traffic growth will result in new equipment investments for the next decade. The total investment required will be determined by carrying capacity (both aggregate and per unit), and equipment utilization rates. Research at this stage can reduce the investment while providing the same throughput. For example, Transport Canada's projections for 1995 grain traffic translate to a need for up to 10,000 new covered hoppers (at 1980 car cycles and average loadings). This is at least a $100 million investment. Increasing the average load by five per cent and improving cycle times from 18 to say 15½ days would cut the new investment requirement in half through the better utilization of the existing hopper car fleet. An increase in the design capacity of the new hopper cars can further reduce the required investment. Similarly, increasing locomotive availability from 85 to 90 per cent, coupled with a modest increase in tractive capacity, would allow a reduction of at least $250 million in locomotive investments over the next decade. More substantive improvements in car weight and capacity, train handling, and aerodynamics could reduce locomotive requirements by another $100 to $200 million. A potential for significant railway productivity improvements has been demonstrated in the past. Since the mid-1960s Canadian railways have

substantially increased traffic carried at an average cost which has increased at only a fraction of inflation.

Multiple payoffs of R&D in various railway sub-systems for productivity, capacity, safety, and regulatory improvements will, of course, favour certain R&D programs. The difficulty lies in establishing the scale of benefits to be derived, particularly in relative terms for different programs. Comparative magnitudes of benefits can be determined through use of the various forecasts. Other determinants of priority are:

- resource availability:
  - funds
  - expertise
- probability of success:
  - technological risk
  - business risk
- window of opportunity/necessity:
  - timeliness of R&D
  - competitive modal technology improvements
- institutional barriers:
  - regulation
  - institutional interaction.

Resource availability will define the overall "budget" available to apply to a bundle of R&D projects. General cost-benefit factors can be qualified/adjusted by the degrees of technological and business risk. The time frame within which specific R&D can be performed has been given special note because of the varying lead times required for different projects. Electronics bread-boarding is many times faster than the design and manufacturing needed for rolling stock development. Within a specific project, the development lead time must be short enough to allow timely implementation.

The work under way in response to the ATCS initiative is an example of the need for the involvement of regulatory authorities during the design, testing and qualification of new signalling and control systems to ensure public safety. If regulatory reform does not stay in step with technical development, the timely introduction of necessary system

improvements may be delayed. The market is too competitive and fast moving to tolerate this.

Discussion of institutional barriers to R&D was included due to the complex interaction of players in the R&D process. The ARFP has directly or implicitly involved a large number of government bodies, the railways, manufacturers, consultants, academics, and others whose objectives and priorities are not always coincidental. Support for and success of specific R&D initiatives will be dependent upon the ability of the ARFP to create significant consensus and commitment within the affected institutions.

A preliminary list of R&D programs was developed in response to government, supply industry, and shipper input. These were presented to the respondees and other industry bodies.

3.2 Recommendations

- Advanced train control sub-systems:
  - coordination and support of Canadian suppliers
- Innovative rolling stock design:
  - development of expertise to generate Canadian designs for emerging specialty equipment markets
- Track system construction/maintenance:
  - optimization of track systems to enhance enormous investment in fixed plant
- Infrastructure configuration:
  - examination of alternatives for matching capacity to demand (high and low)
- Electrification:
  - continued improvement of data base to identify optimal implementation scenario
- Rail freight data base:
  - as part of a larger transportation data base, develop reference data to aid in determining and assessing potential developments

- Materials analysis/development:
  - development of expertise to test/demonstrate novel materials applications to equipment and track design

- Development facilities:
  - provision of focal facility and group to aid firms in the earlier, riskier aspects of technology development.

Response to these recommendations was limited. The single private-sector response from Bombardier (Appendix B) reacted to the sensitive situation concerning locomotive sourcing by CN and CP. The lack of private-sector response is typical of this and similar efforts to identify and implement industrial strategies in Canada.

Given the status of the industry, the above-mentioned priorities may stand as justified by market analyses and forecasts. They represent a matching of railway requirements and industry capabilities to meet the technology challenges for the near to medium term.

4. BIBLIOGRAPHY

Bureau of Management Consulting. Evaluation of ARFP. January 1984.

Canadian Mining Journal. February 1985.

Canadian Resourcecon Ltd. Potential Markets for Thermal Coal in Canada. Prepared for the Canadian Energy Research Institute, 1979.

Driscoll, M.L. Rail Industrial Strategy. CIGGT Report No. 84-17. Prepared for Ontario Ministry of Transportation and Communications, February 1985.

Empy, W.F, et al. The National Economic Impact of Railway Electrification." Transport Canada Report TP 4461-E, May 1983.

Energy, Mines and Resources. Long-Term Energy Supply/Demand Outlook. Spring 1984.

Financial Post. "Report on the Nation." November 1984.

Ontario BILD Program. "Background Paper on Transportation and Resources." January 1981.

RAC/AAR. ATCS Operational Requirement. April 1984.

Review of the Canadian Economy. Organization for Economic Cooperation and Development. Spring 1984.

Statistics Canada. Report No. 52-215.

Transport Canada. Annual Reports. TP 1981/82, 1982/83.

Transport Canada. Freight and Passenger Forecasts - 1984.

Transportation Development Centre, Transport Canada. MSERD Rail Freight Transportation and Development Program (Augmented Rail Freight Transportation and Development Program). TP 3756-E, 1981 to date.

Transportation Development Centre, Transport Canada. Annual Reports. TP 3230, 1980-81, 1981-82, 1982-83.

Transportation Research Board. Rail Transport Research Needs. Report No. 174, 1977.

APPENDIX A

HISTORY OF THE AUGMENTED RAIL FREIGHT PROGRAM

The following is excerpted from the Treasury Board Submission by Transport Canada dated July 13, 1981:

> Rail Freight Transportation R&D Program:
>
> 7. The objective of the Rail Freight TR&D program is to permit the railway supplier and operating industries to produce and deploy equipment and systems which will yield improvements in rail freight regarding productivity, capacity, safety, and costs and improve Canada's ability to compete in domestic and foreign markets. This objective will be achieved by:
>
> a) increasing the federal railway R&D expenditures by participating with industry in a multi-year R&D program;
>
> b) achieving stronger industry commitment to R&D and inducing investment in new Canadian railway technology.

The Augmented Rail Freight Program (ARFP) arose following extensive introspection on federal transportation R&D carried out for the Inter-departmental Panel on Transportation R&D. Railway R&D funding was faring poorly relative to other modes, with minor industry participation. As specified in the Treasury Board submission, the ARFP aimed to induce investment in new railway technology through active participation in the R&D process. By focussing on the commercial partners in the industry structure, it is clear that the R&D was to produce measurable results through system improvements or increased competitive ability of Canadian products.

Research projects were designated within the general categories:

- motive power
- freight cars
- intermodal
- infrastructure and maintenance
- communication and automation.

A sixth program element was budgetted to allow for expert input through program support functions. The current allocations for these six elements are reproduced in Tables A.1 and A.2.

TABLE A.1

SUMMARY OF FUNDING AND RESOURCE CONTRIBUTIONS FOR PROJECTS ACTIVATED TO END OF 1ST QUARTER FY 1984/85 (JUNE 30, 1984)
($000)

Title	TDC Project No.	Total Authorized ARFP	Industry	Other
Activated prior to 1st quarter:		6100.7	1928.7	2349.5
Adjustments during 1st quarter to projects activated prior to start of 1st quarter (Table 2)		(0.4)	-	10.0
Subtotal		6100.3	1928.7	2359.5
Added during 1st quarter		-	-	-
Total		6100.3[1]	1928.7[2]	2359.5[3]

[1] Appendix 1 - Program Summary Table

[2] 1792.2 resource contribution; 165 financial contribution (Table 4)

[3]
301.3 DSS Bridge
812.6 Energy R&D
940.4 TDC O&M
2054.3 Sub-Total Other Federal Funds (Appendix 1 - Program Summary Table)
208.1 NRC Resource Contribution (Table 3)
97.1 Province of Ontario (Table 5)
2359.5

Source: "Augmented Rail Freight Transportation Research and Development Program, First Quarter Report FY 1984/85," Transportation Development Centre, June 30, 1984, TP 3756E

TABLE A.2

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS, AS OF JUNE 30, 1984*

PROGRAM SUMMARY
($000)

	Total Authorized			Actual Disbursements					
				During 1st Quarter FY 84/85 (April 1 - June 30, 1984)			Total to June 30, 1984, Including Previous Years		
	ARFP	Other	Total	ARFP	Other	Total	ARFP	Other	Total
1. Motive Power	1665.3	1447.6	4112.9	8.7	0.0	8.7	2186.1	1037.6	3223.7
2. Freight Cars	740.8	299.5	1040.3	3.1	5.5	8.6	583.6	280.4	864.0
3. Intermodal	391.2	43.0	434.2	0.0	0.0	0.0	183.9	43.0	226.9
4. Infrastructure and Maintenance	707.0	17.3	724.3	1.2	0.0	1.3	661.8	17.3	680.1
5. Communication and Automation	1221.2	246.9	1468.1	18.8	0.0	18.8	1113.9	246.9	1360.8
6. Program Support	374.8	-	374.8	0.0	-	0.0	300.4	-	300.4
Total Program	6100.3	2054.3	8154.6	31.9	5.5	37.4	5030.7	1625.2	6655.9

* Not including NRC Resource Contributions

Source: "Augmented Rail Freight Transportation Research and Development Program, First Quarter Report FY 1984/85," Transportation Development Centre, June 30, 1984, TP 3756E

The report produced by the Bureau of Management Consulting (BMC) in January 1984 recommended that the program be extended. One point of note is their recommendation that the intermodal element be dropped in recognition of the railway's competitive secrecy on this topic. This recommendation was not adopted, as evidenced by the Convoy Canada project and the support of the UTDC HPIT endeavour. Railway competitive secrecy is not a real issue in the discussion of whether or not intermodal research should be supported by ARFP. The technologies under active consideration by the railways are common knowledge to the industry. Transport Canada's concerns should lie with how the evolving intermodal businesses stand with respect to national priorities and concerns. These include the efficient utilization of various infrastructure, i.e. rail versus highway, consideration of future energy scenarios, modal fuel efficiency, the growth of railroad revenue sources for overall system health, and the potential benefits derived from the technology development process.

Motive Power

Program missions are inferred by the funding emphasis within each of the research elements. Motive power projects have pursued topics in electrification and diesel-electric development. It is worthy of note that the electrification project portfolio includes everything from feasibility studies to sub-system and component design. The mission was clearly in place for the first study for the Cartier Railway, and it was maintained through to the BCR implementation. The frenetic activity in the last three years was a result of the tight deadlines established by the commercial situation. The basic requirements for a successful program were all in place:

- secured market (customer)
- technical expertise developed through early studies
- specified deadlines and a large enough development window for implementation
- sufficient financing
- program focus through mission leader.

As a result of this continuing line of development, there now exists an awareness of the economic, technical and logistical issues, and of the resources available for railway electrification. Further discussions with all concerned can now proceed at this higher level of understanding.

An important aspect of the electrification mission is that the provision of electric power represents a new sub-system in the railway environment. Interface with existing systems is mostly confined to the locomotive. Electrification, for the most part, is not an incremental change or improvement to an existing system, and as such its evaluation requires broad systems analyses.

The other major topic in motive power can be generally described as diesel-electric development. In comparison to electrification, there is no one central mission as such, but rather reinforcement of the DRIE objective of creating a product capability in a single supplier. A mission approach requires a clear market signal to drive the program definition. The lack of involvement or validation of the projects by either Canadian railway has aggravated the situation. Blocks of funding have been directed towards diesel engine development, locomotive steerable trucks, ac locomotive control, and shunter locomotive design. The uncertainty of sales at the end of the various developments has called into question the purpose of the program. Whether there can be payoffs for the sunk costs to date will be dependent on the utility of the technology developed thus far.

Freight Cars

A significant part of the ARFP directed at freight car development has dealt with the safety aspect of tank cars engulfed in flames. The opportunity to implement any results of the ongoing research is in doubt due to well-established standards based on work in the U.S. in the early 1970s.

The behaviour of a long train during typical and emergency situations has been difficult to control, leading to undesirable effects on vehicles and tracks. The two projects that address this problem both attempt to develop tools by which the understanding of the problem can be

increased to allow simulated testing of improvements. As the market begins to consider alternate train designs such as the HPIT, these tools will be used in concept evaluation.

Intermodal

The BMC dealt with this issue in their status report. The Convoy Canada project has been questioned by the railways on the basis that the assumptions underlying feasibility are rather sweeping. However, it is clear that significant opportunities exist for improved technology.

Infrastructure and Maintenance

Almost half of the ARFP funds for this element have been for the development of analytical and testing capabilities. There have been a few supply industry contributions to these projects. The railways have participated in projects dealing with specific problems or needs, particularly the improvement of rail life through profile grinding.

It is generally agreed that the broad-ranging considerations of this technology make comprehensive systems research and development difficult. The multiplicity of efforts within the railways could be more effectively coordinated to the leverage of the financial resources available.

Communication and Automation

The 1978 commencement of work on the LIC system anticipated the current activity on Advanced Train Control (ATCS). Successful completion of the B.C. Rail demonstration and reconfiguration of the system for mainline application could make it a contender for some of the ATCS markets. LIC must be brought into line with the ATCS requirements to be marketable.

APPENDIX B

Bombardier Inc.
Division des produits ferroviaires et diesel

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August 20, 1985.

Mr. P. J. Detmold, Chairman
Railway Advisory Board
P.O. Box 6042, Sta. A,
Montreal, Quebec
H3C 3E4

RECEIVED
AUG 23 1985
CIGGT
QUEEN'S UNIVERSITY

Re: CIGGT Report No. 84-20
==========

Dear Sir,

I have reviewed the first draft of the subject report on the "Needs for Rail Freight Development in Canada" which you recently distributed to the RAB for comments. Please accept the following comments representing my personal views as a member of the RAB:

1. The paper addresses the important aspects of the rail freight industry in Canada and is generally quite accurate in defining problem areas and the recommendation of prioritized research tasks as perceived at the present time.

2. Those portions of the paper pertaining specifically to Bombardier R and D activities and resulting from discussions with Mr. Driscoll of CIGGT during his visit to my office on March 27th of this year do, however, leave something to be desired. The second paragraph of section 2.2.3.14 in particular would lead the reader to conclude that sources outside of Bombardier could indeed decide upon the context of Bombardier's ongoing locomotive business.

3. While diesel engine development and power plant design are mentioned in connection with Bombardier on pages 5 and 39, there is no specific mention of the fact that Bombardier is developing and currently has an operational prototype 12 cyl. B2400 engine in it's lab on Dickson street. This is significantly a Canadian development, is unique in Canada, and has the potential for producing horsepower levels that could reliably optimize the performance of A.C. traction systems in future Canadian diesel electric freight locomotives.

.../2.

4. Although mention of AC locomotive control and three-phase traction motors is made on pages 5 and 19 it would seem a disservice to all concerned if the on-going joint AC Traction Evaluation Program sponsored by DRIE was not given specific coverage. Again, this has been uniquely Canadian, representing a joint effort on the part of Brown Boveri/TRM, CP Rail, and Bombardier to retrofit in Canada CP Loco. #4744 for evaluation of the BBC AC traction system specifically adapted for locomotives operating in the Canadian environment.

The attached copy of a letter dated August 7, 1985 recently sent to our Canadian customers will enlighten you with regard to Bombardier's recent corporate decision to withdraw from the manufacture in Canada of freight locomotives for the domestic market.

I look forward to seeing you at the next meeting of the RAB.

Very truly yours,

R. S. Bergner
Director
Engineering Programmes

att.

cc: M. L. Driscoll, CIGGT
R. Klein, CP Research
D. Moriera, BBC/TRM
M.B.P. Watson, DRIE

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August 7th, 1985

Dear Sir,

You are probably aware of Bombardier's corporate decision to withdraw from the manufacture in Canada of freight locomotives for the domestic market. We will however continue to supply Bombardier locomotives to the international market through our worldwide chain of licensees and associates.

We wish to clarify that even though we do not intend to produce locomotives in Canada, we will not relent in our commitments to the Model 251 engine in terms of manufacturing, servicing and technical support, as well as improvements related to this product. In this regard, we are currently developing tooling for new components for the 251 Plus engine for increased reliability and "State of the Art" fuel consumption. These components will be available in 1986.

We will also continue our involvement in the development of the "next generation" diesel engine (code name - B2400) for future use in all applications. The first such engine has recently commenced operational development testing in our Montreal R & D facilities.

We assure you of our long-term support in the supply of spare parts, tools and technical services for the 251 engine and all previously delivered Bombardier, Rail & Diesel Division products.

Yours truly,

Antoine A. Meo
Director
Marketing and Sales

/ed